A history and interpretation of fire frequency in dry eucalypt forests and woodlands of Eastern Tasmania.

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Declaration of originality

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It's over Sahny…

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Abstract

There is scant information available on the occurrence of fire in the Eastern Tiers of Tasmania. Whole, very large and fire scarred eucalypt cross sections were used as source material for the reconstruction of a fire history for this region. Accurate dating of fire scars in *Eucalyptus* has been problematic due to the unreliable nature of the annuality of growth rings. Eucalypts have a proclivity for growth anomalies such as false and or missing rings. The annuality of eucalypt tree rings was assessed using dendrochronological techniques on a sub-set each of young trees <140 yrs (n = 15) and old trees > 150 yrs (n = 27). A software program was developed to assist with data capture and analysis. "Detect Rings" identified ring boundaries and measured ring widths from high resolution photographs. However, the seven sampled eucalypt species (*E. amygdalina, E. obliqua, E. dalrympleana, E. tenuiramis, E. delegatensis, E. pulchella, E. globulus*), were not amenable to within- or between-tree cross-dating.

Multiple radial ring counts from 104 large trees (photographs: n = 27, in situ: n = 77) were aggregated and tested for reliability with a mean error margin of ±7 rings being calculated where tree age was estimated at > 200 years. Additional sources of error were progressively eliminated. The integrity of fire scar capture from thirteen sites, each with variable sample numbers, was addressed by the development and application of a sample size adjustment procedure analogous to the bootstrap. This process indicated that 9-10 sample trees per site were sufficient to detect a high proportion of fire events large enough to generate injurious fire scars. There was no effect on fire scar distribution resulting from tree age, species composition, landscape position, bark thickness, diameter over bark, slope or elevation. The age of the oldest sample tree was estimated to be ~570 years.

The sample size adjustment procedure was used to derive the mean decadal fire years for each tree at each site. Temporal and spatial patterns were then discerned. Temporal patterns were related to variation in annual rainfall. Approximately 29% of

fire years which occurred across three or more sites were related to years of low rainfall indicating a relationship between low rainfall and widespread fires.

A composite fire scar chronology was developed 1740 – 2004 from which distinctly different periods of fire years were defined. Fire years were recorded as mean fire years per decade, per period, thus: 0.7 in the Aboriginal era 1740 – 1820, 0.4 in the Transitional era 1820 – 1850, 1 in the 2^{nd} European era 1850 – 1910, 1.5 in the 3^{rd} European era 1910 – 1990, and 0.7 in the Current or 4^{th} European era 1990 – 2004. Between-decade fire scar variability was highest in the Aboriginal era. The incidence of fire scars massively increased across most sites from the 1850s and continued at high levels until the late 1980s, although a reduced number of fire scars were recorded in the first decade of the 20^{th} C. Occurrence of fire scars in the most recent period, 1990 – 2004, was shown to approximate that of the earliest period 1740 – 1820. These distinctly different temporal periods were interpreted as being caused by cultural activity. Intensive use of the forests for timber-getting co-incided with the Victorian gold-rush of the early 1850s and is the most likely explanation for the sharp increase in fire years at this time. Land use analysis further defined differences in fire years between public and private land with many more fire years being recorded on private land in the first half of the 3^{rd} European period. A tradition of burning for fresh pick in sheep 'run' country, and cultural familiarity with fire, are reflected in this distribution.

Chapter 1

Introduction

1.1 Introduction

"The past exists to fertilise the present"
(G. Dutton cited in Abbott 2003: 119)

Fire frequency is a major component of the fire regime, which also incorporates intensity and season (Gill 1981a). Australia is a fire prone environment (Pyne 1991, 1995, 2003) and plant species have mechanisms for surviving fires at the frequency in which they occur in the various habitats. (Gill 1975, 1981a). The fire regime is a dynamic phenomenon and must be understood as a series of fire events occurring at particular combinations of frequency, intensity and season. Season of fire occurrence is important, particularly in the context of contemporary forest management but is often overlooked (Ortloff 1996; McLoughlin 1998). Fire frequency influences fire intensity because fuel availability is a partial function of time since fire (Whelan 1995). Climate is a factor which cannot be controlled by human beings. Lightning, as an ignition source, is determined by weather which is a function of climate. However, some authors (Miller *et al.* 1999; Johnson *et al.* 1999) suggest that Aboriginal burning practises have changed climate. Particular geographical regions, such as northern Australia, are more prone than Tasmania to fires started by lightning and have known seasons of occurrence (Russell-Smith 2002). Fire frequency in all areas is directly influenced by human beings, because people are a major source of ignition.

Tasmanian dry eucalypt forests have been severely modified by the effects of fires, logging, grazing and clearing for agriculture (Kirkpatrick 1994; Duncan & Brown

1985; Kirkpatrick & Gilfedder 2000). However, little is known about the history of fire frequency in this vegetation type in Tasmania. Prescribed fire in dry eucalypt forests in eastern Tasmania is limited to slash reduction burns after logging and local fuel reduction operations (pers. comm. B. Merritt). These are aimed at protection of natural assets, or occur in reaction to wildfire events which have damaged people or property. An example is the 10,000 ha fuel reduction burn in the hills west of the Scamander region in September 2007 which was undertaken in response to the human-caused wildfires of December 2006. With such notable exceptions, wildfires are generally efficiently extinguished. The prediction of ecological consequences of management activities, such as fire suppression, can be enhanced by an understanding of the disturbance regimes (fire) under which the vegetation has evolved (Gill *et al.* 1991; Covington & Moore 1994; Burrows *et al.* 1999; Mast *et al.* 1999; Bradstock *et al.* 2002; Abbott 2003; Burrows & Abbott 2003).

It is not usually possible to extrapolate information about fire frequency from one ecosystem to another (McBride & Lewis 1984; New 2004). However, there are fuel characteristics of all vegetation types which predispose fire to burn at different intensities (Gill & Moore 1990). It is important to distinguish between the intensities of fires because of the different ecological effects. The intensity of fires was calculated by Byram (1959) and is reported in kilowatts generated per m^{-1}. A low intensity fire approximates < 500 kW m^{-1} and a high intensity fire is defined as > 500 kW m^{-1}. Cheney (1981) further defined fire intensity and measured four categories in kW m^{-1} as low (< 500), moderate (501 – 3000), high (3000 – 7000) and very high (7000 – 70000). The present thesis follows these definitions.

There are several ways in which ecosystems can be affected by changes in fire frequency:

- alteration of environmental conditions, particularly edaphic characteristics and microclimate (e.g. McIntosh *et al.* 2005);
- alterations in species composition and relative abundance (e.g. Ellis 1985; Whelan 1995; Lunt 1998);
- alterations in vegetation structure and (e.g. Duncan & Brown 1995); and,

- reduction or increase in biomass (e.g. Adams & Simmons 1994).

These effects can interact. For example, fire exclusion can promote woody dicotyledonous vegetation at the expense of grasses (e.g. Ellis 1985; Lunt 1998). Cessation of fire can affect ecosystem processes to the point where individual species are susceptible to pests, pathogens and drought, resulting in decline or dieback (e.g. Jurskis 2005).

The nature of ecosystems can be severely modified by alterations to fire regimes and the frequency of fire in particular (Withers & Ashton 1977; Adamson & Fox 1982; Clark & McLoughlin 1986; Bowman & Panton 1993; Gill & Bradstock 1995; Bowman 1998; Gill 1999; Moss *et al.* 2000; Whelan *et al.* 2002) hence, the importance of fire history for management direction (Bradstock *et al.* 1995; Williams & Gill 1995; Abbott 2003; Knox & Morrison 2005).

People have played an important role in the occurrence of fire (Pyne 1991, 1995, 2006). A history of human cultural activity can be deduced from the evidence provided by fire histories (Hallam 1975; Brown & Podger 1982b; Banks 1988, 1990b; Podger *et al.* 1988; Gell *et al.* 1993; Pulsford *et al.* 1993; Burrows *et al.* 1995; Pyne 1993, 1995; Marsden-Smedley & Kirkpatrick 2000; Russell-Smith *et al.* 2002; McLoughlin 2004).

The subject of the present thesis is the history and interpretation of fire occurrence in dry eucalypt forests of Eastern Tasmania.

1.2 Sources of evidence for changes in fire frequency

"Thus fire history, like fire itself, is a maddening amalgamation of human and ecological history; it belongs with the humanities as much as with the sciences." Pyne 1993: 249.

Methods used in the construction of fire histories are related to the time-scale being examined (Lertzman *et al.* 1998). Over evolutionary time-scales palaeoecological, palynological and archaeological techniques are most commonly used to deduce fire histories from fossils and charcoal in their stratigraphic context. For example, from sediment cores, the influence of human beings on fire regimes over hundreds of thousands of years was shown to have been substantial in sub-Saharan Africa (Bird & Cali 1998). Dodson & Mooney (2002) assessed the environmental impact of European settlement, with the aim of estimating changes in the rate of environmental change, by comparing pollen, sedimentation and charcoal accumulation rates with data from the late Holocene for 10 sites in southeastern Australia. While not consistent across all sites, vegetation change was nevertheless associated with regional fire regime changes pre and post European settlement.

On the decades to centuries time-scale, the location of evidence of fire damage in relation to tree ring sequences is commonly used to develop local, regional and landscape-scale fire frequency chronologies. Evidence from ethnographical, ethnohistorical, anthropological sources and contemporary ecological research is often used to interpret the period under examination. Changes in fire frequency may be related to human activity, such as history of colonisation, settlement, management or development (Lertzman *et al.* 1998).

Life history attributes of a species or habitat feature can also be used to determine the likely frequency of fire required to maintain them, or at least not eliminate them, in particular systems (e.g. Inions 1985; Bradstock *et al.* 1996; Burrows & Friend 1998; Whitford 2002; Bradstock *et al.* 2005; Knox & Morrison 2005).

Techniques for deducing changes in fire frequency from tree rings and fire scars are discussed in more detail in subsequent sections. The following section reviews the work that has been done on reconstructing the history of fire frequency and the causes of changes to fire frequency, with a focus on Australia.

1.3 *Interpreting causes of historical fire frequency change*

"Fire and people: to find one was to find the other"
(Wharton 1968 cited in Pyne 1997: 411)

1.3.1 Fire and people or fire and climate?

"...The overall aims...and the actual ways that fires were planned, carried out and controlled, are inseparable in the same way that any technology necessarily involves a relationship of means and ends in a coherent system of perceived causes and effects."
(Lewis 1982a:49)

People have been burning temperate vegetation from ancient times:

"The historic records from around the world leave no room to doubt that primitive hunting and gathering peoples, as well as ancient farmers and herders, for a number of reasons, frequently and intentionally set fire to almost all the vegetation around them which would burn." (Stewart 1963).

That anthropogenic vegetation fires have occurred for many thousands of years (Naveh 1975; Kelsall *et al.* 1977; Gill *et al.* 1981; de v. Booysen & Tainton 1984; Hall 1984; Pyne 1995, 1997) and in the case of Africa, for hundreds of millennia (Maggs 1977) is well accepted. However, in Australia the scale and intentionality of prehistorical indigenous burning in the southern forests is not well known (e.g. Horton 1982; Benson & Redpath 1997). This is, in part, because use of fire by indigenous peoples was recorded in the diaries and journals of early European explorers, surveyors and settlers (Plomley 1966; Hallam 1975: Thomas 1993, 1994; Fensham 1997; Vigilante 2001) by colonising Europeans who were thought to have had no experience of deliberate landscape burning (Thomas 1994). The records therefore, are considered highly subjective and are often discounted as being an unreliable source of evidence for indigenous landscape management (Horton 1982; Benson & Redpath 1997; Gill & Catling 2002). This is an interpretive problem in fire frequency studies because the ignition source of an historic fire event cannot be determined (Clark 1983a; Ogden *et al.* 1998).

Inferences of likely ignition sources can be made from examination of communities of people proximal to fires (Drobyshev *et al.* 2004). For example, Condera & Tinner (2000) found evidence which clearly differentiated the effects of human activity on the fire regime from climatic changes in Switzerland. The study used combined data from palynological research, a lake sediment charcoal profile, and statistically calibrated fossil chronologies to show the strong relationship between anthropogenic indicators and fire frequency since the Neolithic period. Since the mid 20thC fire frequency in Switzerland has dramatically increased which was shown not to be related to increased frequency or duration of dry periods but to well documented changes in landscape management (Condera & Tinner 2000). The relationship between topography, fuels and fire frequency in Missouri, USA was shown to intimately relate to population density and associated cultural behaviour (Guyette *et al.* 2002). Lightning was estimated to account for less than 1% of fires. The authors concluded that population density influenced the recorded increase in fire frequency at around the time of European settlement and described an anthropogenic framework for a fire history spanning 320 years.

The ignition source of relatively modern fires can be determined by observation and estimates made on the likely percentage of these events attributable to causes such as lightning (Swetnam & Baisan 1996:29), rock-falls in the case of the South African forests and fynbos (e.g. Kelsall *et al.* 1977; van Wilgen *et al.* 1992), volcanism or people. This is an important point of emphasis because lightning, as an ignition source, originates under particular climatic conditions and is stochastic in location whereas vegetation fires ignited by people are purposeful and, until the relatively modern (<200 yrs) advent of the arsonist, have constituted ecosystem 'management' for survival (e.g. Stewart 1951; Day 1953; Anderson & Moratto 1996; Bonnickson *et al.* 2000; Gammage 2002).

In some areas, changes in fire frequency have been determined from vegetation dynamics. For example, Mediterranean forests and woodlands have been subjected to anthropogenic fire for many thousands of years (LeHouerou 1973; Pyne 1997). The extensive adaptive responses of vegetation to fire attest to this longevity (Naveh 1975; Gill 1977; Pausas & Vallejo 1999; Pausas *et al.* 2004; Chuvieco 1999). Research aimed at understanding plant functional traits in relation to fire occurrence have shown that resprouting plants are often more abundant than obligate seeders (Kazanis & Arianoutsou 2004) although dominance of rapid maturing seeders in relation to frequent fire can tip species composition toward increased flammability (e.g. *Ulex parviflorus* De Luis *et al.* 2006; Lloret *et al.* 2005). In Greece, *Pinus pinaster* individuals were shown to exhibit different adaptive strategies in response to variation in fire frequency and intensity (Tapias *et al.* 2004). However, there is on-going debate regarding the relationship between fire regimes and evolutionary traits (Buhk *et al.* 2007).

In the Mediterranean basin, most modern wildfires are directly related to the activities of human beings (Le Houerou 1987). Fire regimes are changing in response to demographic change and in some areas forests are expanding because increased standard of living is driving migration to cities. This is resulting in a reduction of forest value and management and the abandonment of arable land. The ultimate consequence of reduced forest value and management is increased fuel loads leading to intense fires (Martin *et al.* 2002.)

Pyne has written extensively (1982, 1991, 1993, 1995, 1997, 2003, 2006) on the global occurrence of fire and its intimate relationship with the cultural, economic, social and political aspects of communities of people. He argues that knowledge and use of fire has contributed to human evolution and that changes to sequences of historical fires cannot be adequately explained without reference to people.

1.3.1.1 The Americas

There are striking similarities in the history of fire between North America and Australia: large areas of fire-maintained forests and woodlands (e.g. Habek & Mutch 1973; Gill *et al.* 1981; Groves 1994), use of fire for landscape management by indigenous inhabitants (e.g. Stewart 1954; Hallam 1975; Plomley 1966; Williams & Hunn 1982; Robson 1983; Anderson 1993; Thomas 1993; Anderson & Moratto 1996; Bonnickson et al. 2000; Stewart 2002) and changes to fire frequency thought to have resulted from the invasion and settlement of European colonists. An exploration of the relevant literature follows, with a focus on the dry forests and woodlands in the western United States, because most fire frequency research has been undertaken in drier areas of National Parks and State Reserves, the largest and earliest established of which occur in this region.

The causes of prehistoric fires, and the degree to which Native American people used fire and influenced fire frequency in North America has been, and continues to be, a polarising issue (Stewart 1954, 1963; Anderson & Moratto 1996; Denevan 1992; Vale 2000; Keeley 2002; Anderson 2002; Lewis 2002; Williams 2005). Burning by Indians in California has been argued to have modified some vegetation communities (e.g. Cooper 1960; Lewis 1973; Keeley 2002) while others contend that Indian burning practises were influential in altering vegetation only at the very local level (e.g. Swetnam & Baisan 1996:29; Vale 2000), if at all (e.g. Johnson *et al.* 1990; Weir *et al.* 1995). Others (Swetnam 1993; Vale 2000) argue that the occurrence of lightning has played a far more dominant role in fire incidence and vegetation dynamics than prehistoric burning by people.

Through extensive qualitative research with indigenous peoples, Lewis (1982b) contended that indigenous Americans were very purposeful in their use of vegetation fire. In the west and south of the United States, exposure to disease from Europeans drastically reduced Indian populations in the mid 1800s (Carroll *et al.* 2002). Use of fire by native Americans effectively ceased from around 1850 when reservations were set aside and remaining tribes were forcibly moved on to them (Day 1953; Vankat 1977; Ryan 2002).

Changes in fire frequency in the western forests in the recent past (spanning ~600 – ~200 years) have been measured through the reconstruction of local and regional fire histories from fire scars embedded in tree stems (e.g. Swetnam & Baisan 1996; Barrett *et al.* 1997) and from counts of tree rings (e.g. Wagener 1961; Kilgore & Taylor 1979; Weisberg & Swanson 2003). Fire frequency changes throughout the western United States have been thoroughly documented (e.g. Mutch 1970; Arno & Sneck 1977; Alexander 1979; Aron 1980; Stokes & Dieterich 1980; USDA Forest Service 1981, 2006; Fritts & Swetnam 1989; Schweingruber 1989; Caprio & Swetnam 1995; Brown *et al.* 1995; Grissino-Mayer 1995; Swetnam & Baisan 1996; 2003; Barrett *et al.* 1997; Stephens & Collins 2004). Most of the many fire histories from the western US show that a massive reduction in fire frequency was co-incident with European settlement and land use (Brown *et al.* 1999).

Such changes in fire frequency at around the close of the 19th Century have been attributed to a country-wide policy of fire suppression (Show & Kotok 1930) co-incident with an increase in grazing pressure (Swetnam 1990). It is thought that large numbers of domestic grazing livestock reduced the continuity of grassy fuels (Vankat 1977; Kilgore & Taylor 1979; Swetnam 1990; Touchan *et al.* 1993; Murray *et al.* 1998). Fire was generally feared amongst early Europeans and declared destructive (Pyne 1982). Changes to vegetation structure and distribution resulting from grazing pressure and fire exclusion were noted in the western forests in the early 1920s (e.g. Leopold 1924). The effects of fire exclusion in Rocky Mountain ecosystems were diverse and extensive (Keane *et al.* 2002).

In the east, Oak savannas were maintained by frequent fire (Wolf 2004) and the effects of human-induced fire reduction, or exclusion, have been conversion from savanna to woodland since European settlement (Henderson 1982; Hicks 2000). Palynological studies at many locations in the north and southeast of the United States have recorded similar phenomena including a shift from pine forests to hardwoods (Clark 1996b; Delcourt & Delcourt 1997) attributed to changes in fire frequency.

Fire scars detected in tree rings, which were used to construct most of the documented fire histories mentioned earlier, are widely thought to have originated from lightning (Swetnam 1990; Swetnam & Betancourt 1990; Swetnam & Baisan 1996; Allen 2002; McKenzie 2004). This reliance on lightning, as a function of climate, as a primary causal agent is hampered by inconsistencies in record-keeping of lightning-caused fires due to differences in reporting processes between federal and state agencies (Main & Haines 1976). Many authors believe that Indians did not influence the frequency of fire prior to their dispossession of their lands (e.g. Johnson & Larsen 1991; Denevan 1992; Swetnam & Baisan 1996; Kretch 1999; Baker & Shinneman 2004). Nevertheless, other authors note a co-incidence of indigenous population reduction, due to disease, with reduced fire frequency (Stephens & Collins 2004; Wolf 2004). Grissino-Mayer (1995) used a wide range of historical information to interpret patterns of fire in El Mapais Monument, New Mexico. Relatively recent fire frequency fluctuations were found from fire scars in conifers and explained using climate and land use history (Grissino-Mayer 1995). The length of the study spanned six centuries and climate was thought to have played a more significant role than people in the earliest four hundred years. Documented Mexican and European historic land use change, and records of grazing animal numbers in particular, were integral to explaining the pattern of fire scar incidence throughout the two most recent centuries including a reduction in fire frequency, attributable to fire exclusion, from about 1940. Indian fires were not considered influential. Climate driven lightning was the attributed cause of pre-European fires (Grissino-Mayer 1995).

The earlier prevailing view of America as a pristine wilderness where Indians were subjected to the vagaries of their environment has clouded ecological thinking (Gillson & Willis 2004). A view of Indians as managers of vast landscapes which they moulded and managed with fire appears in the literature (e.g. Williams 2005) with the collective message that Indians burned frequently because their lives and livelihoods depended on the results of such activity (Lewis 1982a, 1985; Anderson & Moratto 1996; Bonnickson *et al.* 2000; Hicks 2000; Stewart 2002). Their fires were of low intensity, possibly of insufficient intensity to always scar the trees which were sampled to determine fire histories from which fire frequency changes were interpreted. Douglas Fir (*Pseudotsuga menziesii*) and Ponderosa Pine (*Pinus ponderosa*) in drier areas have very thick and fire-resistant bark, as do most *Quercus* species (Spalt & Reifsnyder 1962) which could preclude detection of non-injurious fires (Wagener 1961; Vines 1968; Henderson 1982; Stephens *et al.* 2003). Fire histories could be incomplete as a result (Baker & Ehle 2001).

Lack of evidence of historic fire scars does not mean that fires have not occurred. The ethnohistorical, ethnographic or anthropological accounts of fire in early contact American landscapes have occasionally been invoked to assist with interpretation of vegetation change in association with changed fire frequency. In part, this is due to the length of tree ring studies. These often lack samples prior to the late 1700s (Stewart 2002:54; Clark & Royall 1995). A cross-disciplinary approach could provide material which assists with interpretation of fire frequency change from tree rings despite the subjectivity inherent in using historical information (Watson 1969).

In the south and southeast of the United States, changes in fire frequency from multidisciplinary sources were synthesised by Fowler & Konopik (2007). Changes in fire frequency were interpreted to be caused by people through shifts in cultural traditions. These were documented from a holistic approach which recognised the complex relationships between history, society, politics, economy and ecology. Five distinctly different periods of human-caused fire regimes from 12,500 BP to the present day were identified from the literature. It is difficult to ignore the co-incidence of cultural activity and changes in fire frequency at particular periods. Whilst acknowledging that lightning fires form a component of any fire regime, the authors attest that such fires vary both temporally and spatially and that it is human-ignited fires which cause ecosystem changes. The authors conclude that "*The South has been a cultural landscape and people have been a 'natural' part of fire regimes for a very long time*" (Fowler & Konopik (2007:174).

Increasing wildfire size and severity in recent years (< 60 yrs) has been widely reported from tree ring evidence (Kolb *et al.* 1994; Swetnam *et al.* 1999; Ryan 2002; Grissino-Mayer *et al.* 2004) and has been attributed to changes in ecosystem structure and increased fuel loads resulting from the effectiveness of the fire suppression policy (Taylor 2000, 2004; Moore *et al.* 2004; Wells *et al.* 2004). Others contend that more research is needed before these hypotheses can be accepted (Reed 1998; Baker & Ehle 2001; Vale 2002; Baker 2006). For example, several authors question the fire scar based methodology used to obtain evidence of increased fire spread and severity because these methods can fail to capture all fires (Baker & Ehle 2001; Baker & Shinneman 2004). Sampling bias and the potential for low intensity fires to burn without causing tree scarring are the main areas of contention. Because sufficient empirical pre-European data on fire frequency or severity is not available for comparison it is thought impossible to gauge whether an observed contemporary fire regime of high intensity fires is natural or an artefact of fire exclusion. Baker & Shinneman (2004) concluded that national fire management plans could be based on premature and possibly wrong data about the natural fire regime in piñion-juniper woodlands in the southwest. Indian use of this vast ecosystem was not mentioned (Baker & Shinneman 2004). Another study did not find any change in fire frequency since European settlement in the northwest forests but concluded that sampling bias could have contributed to these results (Arabas *et al.* 2005).

The effect of a warming climate is thought to provide conditions conducive to increased fire frequency and spread by affecting fuel properties and affording heightened opportunity for ignition. A strong correlation exists between the occurrence and extent of fires and the El Niño Southern Oscillation Index (ENSO) in the southwestern USA (Swetnam & Betancourt 1990, 1992) and in parts of South America (Kitzberger & Veblen 2003). There is also a relationship between the Palmer Drought Severity Index (PDSI) and fires in the western United States (Westerling *et al.* 2002). These relationships are the reason why climate alone is so often interpreted as a causal factor in fire frequency change detected in ecological systems in the United States and Canada.

That the European incursion of the late 1880s resulted in changed fire frequency is not a foregone conclusion for eastern and western Canada, although, in some areas such as Jasper National Park, miners, railroad builders and settlers were considered responsible for a small regional increase in fire occurrence between 1880-1910, based on fire scar evidence (Tande 1980). In contrast, time-since-fire maps derived from stand age data for central southwest Canada, revealed no change in fire frequency since the mid 1700s (Weir *et al.* 1995).

In Glacier National Park, Johnson *et al.* (1990) attributed an increase in fire frequency in the 1880s, co-incident with human activity, to lightning associated with the end of the 'Little Ice-age' (Luckman 1986). In Alberta, Johnson & Larson (1991) ascribe reduced fire frequency from the early 1700s to the 1980s as a response to increasing cold as evidenced by glacier advance (Osborne & Luckman 1988). Because of a lack of substantiated evidence as to why Indians "*...would have caused fires as part of their lifestyles*", Indian burning was discounted as having influenced the fire frequency in the region although the potential for a smallpox outbreak to have reduced the population of the local tribe and consequent use of the study area was explored (Johnson & Larson 1991). The authors concluded that European activity had no effect on the fire frequency after 1882. Reed (1998) advised caution in conferring a human cause to the increased fire frequency co-incident with human settlement and railroad construction found in the 1880s in Glacier National Park despite reporting on a model which statistically determined fire history epochs related to human activity from stand age data. Furthermore, he suggested that interpretation of reduced fire frequency from the 1940s, reported elsewhere for Canada (Masters 1990; Bergeron & Archambault 1993) cannot be attributed to the success of fire exclusion without more evidence.

From tree ring evidence, fire frequency has been shown to have considerably decreased since 1850 in eastern Canada (Bergeron *et al.* 2001; 2004). Human activity was considered an unlikely influence because the native peoples were purportedly few in number and European settlers had apparently not yet reached these forests (Lesieur *et al.* 2002). Therefore, a reduction in lightning ignited fires associated with climatic wetting and warming at the close of the "Little Ice-age" was the attributed cause. Increases in fire frequency have occurred very locally in some areas co-incident with periods of European settlement (Bergeron *et al.* 2001; Grenier *et al.* 2005).

Many Canadian forest fire histories have been developed using the fire cycle method (Johnson & Gutsell 1994). Recently, Reed (2006) has recommended that the concept of the fire cycle (the time required to burn an area equal in size to the study area) derived from time-since-fire maps, be abandoned because the concept is confusing, has not widely been accepted (Lertzman *et al.* 1998) and cannot account for the random nature of fires.

Climate is thought to play an important short-term role in influencing fire frequency in Patagonia (Veblen *et al.* 1999). However, when the tree ring data were examined over the decades to centuries scale, people were thought to have had a more significant impact on the frequency of fire than climate.

1.3.2 Australia

1.3.2.1 Review of Australian literature in relation to forests and woodlands

The frequency of fire in the landscape over long time frames (> 500 yrs) has been determined for many areas of Australia from the palaeo disciplines (Dodson &

Mooney 2002). One such landmark palynological study, spanning a 350,000 year period and covering three distinct phases, showed how the incidence of charcoal dramatically increased (Singh *et al.* 1981) concurrent with eucalypt pollen 120,000 yrs/BP at Lake George in New South Wales. Aborigines were speculated to have arrived in Australia at this time although the chronology has a lack of precision which precludes certainty (Clark 1983a). Nevertheless, the levels of charcoal found in deposits during the most recent 200 years were 16 times higher than in the pre human period and 3.5 times higher than in the Aboriginal period (Singh *et al.* 1981).

In Australia, tree ring counts have been used in sub-alpine, sub-tropical and Mediterranean-type climates, with both conifers (Pulsford *et al.* 1993; Bowman & Panton 1993; Hua *et al.* 2003) and eucalypts (McBride & Lewis 1984; Podger *et al.* 1988; Woodgate *et al.* 1994; Burrows *et al.* 1995). The number of tree rings between bark and pith can be used to determine tree age (Rayner 1992; Whitford 2002; Koch 2007), provide a record for local and regional synchronous fire events (Pulsford *et al.* 1993, Banks 1993; Burrows *et al.* 1995), and can be used to determine coarse-scale fire interval changes pre and post European settlement (Podger *et al.* 1988; Hickey et al. 1999; Alcorn *et al.* 2001). Gilbert (1959) used tree rings to age *E. regnans* and several rainforest trees from parts of southern Tasmania and concluded that very widespread fires occurred around 1804, causing the even-aged regeneration he was examining.

In south-west Western Australia, ring counts indicated that the mean interval between injurious fires in *Eucalyptus marginata* forests of 81 years under pre-European conditions decreased to around 17 years after the settlement of Europeans in response to logging and the burning of slash (Burrows *et al.* 1995). They postulated, given the climate and vegetation of the region, that a combination of Aboriginal initiated fires and lightning maintained low fuel loads which would generally have carried low intensity fires. Such fires would have a reduced capacity to scar the eucalypts.

Woodgate *et al.* (1994) counted rings of *E. sieberi* samples and concluded that no change in fire frequency was evident since European settlement in an area of East Gippsland, Victoria. The sample size was very small at eight. Those studies which have interpreted fire frequency change using the historical record have cited and described cultural factors, often dividing the chronology into cultural periods or eras of land use practices. For example, Banks (1982) used ring count evidence to deduce that fire frequency increased in the 1850s in the Brindabella Ranges and attributed this to increased activity generated by gold seekers.

Species of the genus *Callitris* have been used in the Northern Territory (Bowman & Panton 1993) and the Snowy River valley in New South Wales (Pulsford *et al.* 1993) to elucidate differences in pre and post colonisation fire frequency. Stand ages, derived from cross-matched tree ring counts revealed that fire frequency reduced following settlement in the Northern Territory. This resulted in a high density of juveniles and geographic contraction of *C. intratropica* (Bowman & Panton 1993). From fire scars, estimated stand establishment dates and the historical record, it was proposed that the combined effects of frequent human-ignited fire from the 1840s, severe rabbit browsing and cattle grazing created ground cover loss in the lower Snowy River Valley which enabled soil erosion, subsequent tree stress and degradation of old growth stands of *C. glaucophylla* (Pulsford *et al.* 1993).

In recent times (<40 yrs) mapping of fire events has become very accurate due to the development and accessibility of satellite technology, which is used to remotely capture landscape images, and geographic information systems which are used to analyse remotely sensed data (e.g. Kitchin & Reid 1999; Fensham & Fairfax 2002). Changes in fire occurrence have ben detected using fire mapping, most notably across northern Australia (Russell-Smith 2002), and in western Australia (Gill 2002) in fire season, extent and frequency. Changes in the temporal and spatial occurrence of fires across northern Australia have also been related to those in southeast Australia to highlight the differences in regime characteristics in relation to population and fire management funding (Russell-Smith *et al.* 2007). Fire mapping is still a relatively recent phenomenon but is growing due to the increasing availability of satellite imagery (Bradstock *et al.* 2005). Fire mapping can effectively only cover those fires which have occurred since the 1940s (aerial photography) or since the 1980s (satellite imagery).

There has been very little quantitative research on the history of fire frequency in Tasmania generally and equally little in dry eucalypt forests in Australia as a whole. Major changes in fire frequency in the recent past have been proposed since settlement of Europeans in Australia in the early 19th century (e.g. Banks 1982, Hallam 1985, Burrows *et al.* 1995).

At present, much of what is known about fire history in Tasmania is derived from charcoal analysis of wetland sediment cores (e.g. Bowdler 1984; Clark 1983b), pollen core analysis (e.g. MacPhail 1976; Colhoun and Van de Geer 1986; Dodson 2001), radiocarbon dating techniques (e.g. Sigleo and Colhoun 1985), paleoecological reconstructions (e.g. Cosgrove *et al.* 1990; Thomas 1991), synthesised ethnohistorical records (e.g. Thomas 1994) and, to a lesser degree, oral history of the Aboriginal people. There is variability in the timing of changes in chronologies developed from such work. Most agree that over long time frames, changes in plant composition and charcoal accumulation rates have occurred (eg. Singh *et al.* 1981; Head 1989; Jones 1985; Gell *et al.* 1993; Bradstock *et al.* 1996; Miller *et al.* 1999; Miller *et al.* 2005; Mooney *et al.* 2007). However, the causes of such changes differ and are variously attributed to climate or people. One high resolution study in northern Tasmania provided evidence for a massive increase in charcoal deposition (14.3 times) between pre and post European settlement by measuring and adjusting sedimentation accumulation rates (Moss *et al.* 2007). In addition, a ~20 year transition period at around the time of European colonisation marked a distinct hiatus between the earlier and later types of land use.

Recent (< 300 years) fire history in Tasmania has been variously interpreted from vegetation change (Brown & Podger 1982a; Podger *et al.* 1988; Marsden-Smedley 1998), stand dynamics (Hickey *et al.* 1999; Duncan & Brown 1995) and by dating fire scars embedded in eucalypt tree rings from cohort age (Alcorn *et al.* 2001).

Such techniques generally lack a high degree of precision but have nevertheless provided valuable information.

Regional fire histories were constructed for southern and south-western Tasmania (Podger *et al.* 1988; Marsden-Smedley 1998) where post settlement fire regime changes were shown to have facilitated the displacement of one vegetation type for another. The Hogsback Plain study showed that sedgeland replaced rainforest resulting from increased fire incidence after European settlement (Podger *et al.* 1988). In the southwest of Tasmania, the complex mosaic of alpine vegetation, buttongrass moorland, ti-tree scrub, eucalypt forest and rainforest is thought to have been altered by the combined effects of fire exclusion following the removal of Aborigines (Marsden-Smedley & Kirkpatrick 2000) followed by frequent fires during extensive mineral exploration after the 1850s.

The importance of the fire regime in Australia in shaping and maintaining vegetation structure and distribution has been most well understood in south-west Western Australia where fire records have been maintained since the 1930s and an extensive body of research (Ford 1985; Burrows *et al.* 1989; Christensen and Abbott 1989; Gill 2002; Burrows & Abbott 2003) has been undertaken in order to provide contribution and direction for forest managers. Interpretation of historic and pre-historic (pre 1827) fire regimes, from ring counts and fire scars embedded in the tree rings of Jarrah (*Eucalyptus marginata*) (Burrows *et al.* 1995) and blackened leaf bases from the stems of grass-trees (*Xanthorrhoea preissii*) (Ward & van Didden 1997; Lamont *et al.* 2003), have been used to deduce changes in fire frequency in the Jarrah forest belt. Burrows *et al.* (1995) interpreted the pre-settlement frequency of fire as variable, but primarily comprised frequent low intensity burns (evidence of which was <u>not</u> found as scars in the fire resistant Jarrah stems, but which was seen on the blackened leaf bases of the grass-trees examined by Ward & van Didden 1997) with an occasional high intensity fire.

This interpretation of the grass-tree work (Ward & van Didden 1997; Lamont *et al.* 2003) was not immediately accepted. Recent evidence based on life history attributes of several shrub species has shown how the high fire frequency proposed by the grass tree evidence would potentially result in the elimination of three *Banksia* species (Enright *et al.* 2005).

The concern of Enright *et al.* (2005) over incompatibly high fire frequency with the life history attributes of the *Banksia* spp. is ongoing. Both Enright *et al.* (2006) and Ward (2006) have defended their original reports leaving the issue currently publicly unresolved. Perhaps there is room for mediation in the interpretation of fire behaviour in the type of landscape used in the original studies. The type and arrangement of fuel is likely to result in very patchy fire movement accommodating both views.

1.3.3 Fire regime variability

The biota which comprise dry forest ecosystems have evolved under climatic conditions during periods of both cooling and warming over long evolutionary timeframes (e.g. Singh *et al.* 1981; Colhoun & van der Geer 1987; Kershaw *et al.* 2002). Before the arrival of people in Australia, landforms and climate probably determined the occurrence of fires. Plant species in dry eucalypt forests have developed diverse properties (e.g. volatile oils or bark shedding) and characteristics (e.g. lignotubers or serotinous seed production) which enable their persistence after fire (Gill 1975). To accommodate the wide diversity of survival requirements by co-existing plants and animals, a degree of spatial and temporal variability in the occurrence and properties of fire must historically have taken place. Past variability in fire season, frequency and intensity partly account for the diversity of species life history attributes found in dry forest ecosystems (Burrows & Friend 1998) while substrate and soil properties are also an important factor in plant distribution (e.g. Laffan *et al.* 1998).

It has been proposed (Lertzman *et al.* 1998) that interpretation of variability in fire frequency is relevant to the time scale being examined. For example, palaeoecological reconstructions of fire frequency over a few decades may lead to interpretation of temporal variability as noise while over several hundred years the same variability may indicate definite patterns. A multi-disciplinary approach may assist with an account of temporal variability, although not always (e.g. Lepofsky *et al.* 2003). Predictive models are useful although are often based on a number of assumptions. Models can nevertheless incorporate a wide range of parameters, including the seasonal nature of lightning and the likely influence of climate, but may never be able to fully accommodate the character of ignitions by human beings. The melding of quantifiable ecological variables, such as fire scar data from tree rings with information from other disciplines, such as cultural trends and traditions from ethnohistorical sources, helps to attain a more complete representation of historic fire frequency variability because the human factor is included in the analysis. For example, a comparison of modelled fire frequency (FIRESCAPE) and actual fire frequency derived from fire scars revealed that the influence of climate through lightning ignitions probably plays a secondary role to that of people in determining the frequency of forest fires in southeastern Australia (Cary & Banks 2000).

1.4 Methods for determining fire frequency change

A variety of methods have been used to reconstruct the incidence of fire over the longest timeframe permitted by the choice of proxy. Dendrochronology (dendro = tree from the Greek, chronology = sequence of events through time) offers precision in the dating of fire scars in tree rings but is immensely time-consuming while the averaging of counted tree rings over several radii on tree cross-sections is relatively quick but is subject to compromised precision especially where the annual nature of rings is in question (Schweingruber 1989).

1.4.1 Dendrochronology

Trees are remarkable recorders of their experience. Flooding (Holmes *et al.* 1982; Argent 1995) soil erosion (Warren 1961) climactic fluctuations (Fritts 1976, Cook *et al.* 1991) upper atmospheric calamity (asteroids and volcanoes eg. Baillie & Munro 1988; La Marche & Hirschboeck 1984) ground and air pollution (Thompson 1981) and fire (eg: Stokes & Dieterich 1980) are all environmental events which impact on tree growth and the properties of tree rings. Dendrochronology is used extensively in reconstructions of sequences of historical events (e.g. Baillie 1982; Fritts & Swetnam 1989) and climatic conditions (e.g. Fritts 1976; Hughes *et al.* 1982) with conifers being particularly amenable to this method due to their global distribution and proclivity for reliable annual rings.

The cross-dating of annual tree rings is a technique which enables allocation of an exact year to each increment of annual growth (Douglass 1941a, b; Fritts 1976) and is the fundamental principal of dendrochronology. The matching of patterns - wide and narrow rings or the particular characteristics of an individual ring - from one tree to another is a cross-reference for the determination of missing or false rings in a sequence. 'Signal' or 'marker' rings are widely used on a local or regional basis to indicate the likelihood (and extent) of a climatic event such as a fire (Banks 1982; Burrows *et al.* 1995), frost (La Marche & Hirschboeck 1984), extreme cold (Buckley 1997; Allen unpublished data) or drought (Cook & Jacoby 1977).

Trees susceptible to cambium damage resulting from fires, sustain scarring in the growth ring of that year, leaving a record of fire year. Dendrochronology has successfully been used to reconstruct fire histories in conifer forests from many parts of the northern and southern Americas, Asia and Europe, and in eucalypt forests of eastern Australia (Banks 1982; Banks 1990b). The cross-dating method provides for a high degree of accuracy in the allocation of a calendar year to sequential tree rings (Douglass 1941a, b; Stokes & Smiley 1968; Fritts 1976). Thus events such as the passing of an injurious fire can be dated from the resultant scar embedded in the wood (e.g. Stokes and Dieterich 1980; McBride 1983; Brown and Swetnam 1994; Grissino-Mayer 1995; Fulé *et al.* 2003).

In Australia, conifers are usually killed by intense fire and are therefore not generally used to reconstruct fire histories. They are suited to climatic reconstructions due to their longevity (> 1000 years), sensitivity to drought, and distribution in areas of high rainfall (e.g. *Athrotaxis selaginoides, Athrotaxis cupressoides, Lagarostrobos franklinii, Phyllocladus aspleniifolius*). This technique has been employed in Tasmania to generate climate histories using Huon Pine, *L. franklinii* (Cook *et al.* 1991) and to explore climate relationships with Celery Top Pine, *P. aspleniifolius* (Allen 1998) but have not been widely used to elucidate fire history from eucalypts.

1.4.1.1 Fire history reconstruction methods in debate

Methods for determining a fire history from trees are based on either dendrochronologically dated fire scars (e.g. McBride 1983) or estimates of fire dates based on mean ring counts over several radii on each individual sample, from one or more sites (e.g. Arno & Sneck 1977; Banks 1982). A site usually consists of individual standing trees or stumps. A fire scar chronology for each tree is calculated (e.g. Arno & Sneck 1977) and a composite site fire chronology results from the pooling of individual tree chronologies (e.g. Dieterich 1980). From the composite chronology the mean frequency of fire occurrence over the site and study area can be determined. Contemporary and historical sources are then used to interpret the patterns of mean fire frequency over the length of the composite chronology.

There is contention regarding the accuracy of this commonly used method of determining fire frequency (Baker & Ehle 2001; Baker & Shinneman 2004; Baker 2006; van Horne & Fulé 2006; Fulé *et al.* 2006). Firstly, published terminology is often confusing despite an attempt made by the Ad Hoc Committee (Romme 1980) to qualify and refine definitions. Different terms are used by different authors to describe how frequently a fire burns at a point in the landscape or covers a defined area of study. For example, the terms 'fire rotation' and 'population mean fire interval' as used by Baker & Ehle (2001) and 'fire cycle' as used by Johnson *et al.* (1990), Johnson & Larson (1991), Johnson & Gutsell (1994), Reed (1998), Reed *et al.* (1998) and Baker & Ehle (2001) all mean that fire frequency is dependent on the size of the study area and is determined by the length of the period required for the area in question to be 100% burned – the temporal aspect of the frequency of fire is intertwined with the (estimated) spatial extent of each fire.

Secondly, the concepts of fire rotation and fire cycle are complex, rely on extensive statistical analyses and have not been widely taken up (Lertzman *et al.* 1998). A focus on statistical analysis can cloud or colour temporal characteristics of fire frequency at the expense of "*...understanding the past dynamics and current structure of ecosystems.*" (Swetnam & Baisan 1996). The fire cycle or fire rotation method is dependent on overly complicated statistical analysis which has served to produce widely divergent fire frequency estimates when compared with those derived from the point based composite fire interval method, as described on the preceding page. For example, for the same area of *P. ponderosa* forest in Grand Canyon National Park, Baker (2006) proposed a 'fire rotation' (fire frequency) at any given point as being between 55 – 110 years. This varies considerably from the mean fire frequency proposed by Fulé *et al.* (2002, 2003) of 18.4 years using the composite fire frequency method. An added complication is the proposed 'bracketing' of uncertainty, demonstrated in Baker & Ehle (2001) in an attempt to account for 1) the periods either side of the stated length of the fire history and 2) potential unrecorded fires. Stated as 'population mean' and 'fire rotation' Baker & Ehle (2001) report that for the same data set a composite fire interval of between 5- 21 years equates to between 22.5 – 94.5 years at the low end and between 48 – 308 years at the high end. These figures were proposed as an alternative to the composite fire interval method because they had been derived from analyses designed to account for uncertainty. Reed (2006) has recently recommended that the concept of the fire cycle, and by association fire rotation, be abandoned due to its overly complex nature.

1.4.2 Eucalypts as source material for a fire history

It has been suggested that eucalypts show little promise for dendroecological studies (Dunwiddie & LaMarche 1980; Hughes *et al.* 1982; LaMarche *et al.* 1979; Norton 1990; Ogden 1978, 1982; Schweingruber 1992). Despite this, climate relationships (Keith 1982; Strasser 1992; Semple 1994; Smith 1997; Brookhouse & Brack 2006) and fire histories (Banks 1982) have been developed for areas of New South Wales and the Australian Capital Territory using dendrochronological techniques. In addition, tree and stand ages and fire frequency were estimated from ring counts and cross matched ring width patterns in the forestry tree species *E. diversicolor* in southwest Western Australia (Rayner 1992).

Cross-sections of *E. pauciflora* from sites close to Canberra were used to relate ring width patterns to rainfall (Keith 1982; Smith 1997) and soil moisture (Strasser 1992). No significant relationship between ring-width data and climatic variables (rainfall and temperature) was found (Keith 1982), although a weak spring/autumn rainfall correlation with the widest 20% of rings was identified (Smith 1997). As a factor in defining wood properties such as ring width, soil moisture is highly important (Zobel & van Buijtenen 1989: 197). Significant relationships were identified when mean ring width data was modelled with soil moisture for *E. pauciflora* in the Brindabella Range (Strasser 1992). Semple (1994) used *E. rossii* and *E. mannifera* from a dry sclerophyll forest in south-eastern N.S.W. to look at the relationships between tree ring widths and rainfall. Responses to moisture stress differed between species and between sites. Preceding summer temperatures were significantly related to tree ring growth in *E. obliqua* and *E. delegatensis* sampled from the Central Highlands in Victoria (Brookhouse & Brack 2006) where the first account of successful inter-specific cross-dating in eucalypts has been reported.

Whilst unsuccessful in determining universal signal or marker years from a composite data set derived from Karri (*E. diversicolor*) cross-sections in the south west of Western Australia, Rayner (1992) cross matched ring width patterns, fire scars and drought marker years within and between selected samples to estimate stand ages. The difficulty of working with a range of data sets compiled from different methodologies and from different sources resulted in a comment that the relative frequency of events was more important than assigning actual dates to individual tree rings. He notes however, that '...*precise estimates*...' of tree age are required in stem analysis for mensurational purposes because development of model projections could otherwise be biased. Significantly, fire scars were largely absent from trees before 1850. Several hypotheses were suggested:

- sampled old trees escaped scarring due to the lack of fuel in close proximity to their boles;
- rotted pith obscured or obliterated early fire evidence; and
- the forests experienced frequent low intensity fires which did not cause scarring at sampling height.

This latter explanation is considered the most likely by Christensen and Annels (1985) and by Burrows *et al.* (1995).

Banks (1982) matched ring widths from high altitude cross-sectioned samples of Snow Gum (*E. pauciflora*) in the Brindabella Ranges. He recorded cross-datable signal or 'marker' rings from within and between samples. The trees were aged and fire scars were dated. Where fire scars were unreadable due to damage from subsequent fires, he discerned growth pulse ring patterns and determined that the increased availability of nutrients and reduced competition after a fire event produced a characteristic growth pulse. He found that injurious fires were infrequent prior to European influence but increased markedly around the 1860s with the onset of cattle grazing and mineral prospecting in the region. A significant observation from this work was that the aggregate data provided a regional fire history, reported as a mean fire interval in years, for the Brindabella Range but that individual site fire histories varied enormously. Land use history from a range of sources was used extensively as a collaborative and interpretive aid (Banks 1988).

Eucalypts are susceptible to repeated fire scarring, fungal attack and termite activity resulting in areas of extensive rot which negatively impacts on sample quality. Opportunities for the use of dendrochronology in Australia for the purpose of fire history reconstruction are limited because the eucalypt is a hardwood and not suited to coring which is the non-destructive means of extracting a sample of sequential tree rings from living trees. Whole tree cross-sections are the alternative source of tree ring information. Stumps therefore, are likely to be located in the quantities required in areas of forestry operations. The logging of trees of suitable old age is a highly contested issue in Australia generally and in Tasmania most particularly, and, in the foreseeable future, a method for non-destructive sampling will most likely need to be devised.

Another prospect for stump supply is farm paddocks which have been cleared of old-growth forest for pasture development although large stumps are required to attain a meaningful length of record. The value of farm paddock stumps is reduced with time through weathering which is a natural consequence of exposure and the activity of decay causing organisms.

1.4.3 Tree ring counting

The counting of tree rings has been widely used in the Americas to develop fire histories by dating fire scars (Wagener 1961; Kilgore & Taylor 1979; Parsons & DeBenedetti 1979; Madany *et al.* 1982, Stokes & Dieterich 1980, Weisberg & Swanson 2003; Gonzalez *et al.* 2005). A comparative study between the methods of ring counting and dendrochronology in conifers (Madany *et al.* 1982) revealed that over several centuries the mean difference in the two methods was just 1 ring.

An adaptive approach to fire history reconstruction has generally been taken in Australia. Cross-dating is not reported although cross-matching (partial synchrony of ring width series) is sometimes reported as having occurred visually (Brookhouse 2006). Individual ring characteristics, resulting from the effects of drought (Rayner 1992; Brookhouse 1997), insect attack (Morrow & La Marche 1978) or frost and ring structure differences (Argent 1995; Baalman 1997) have been used for within and between cross-matching. As far as can be ascertained, cross-matching describes the method of visually comparing ring sequences or individual ring characteristics in eucalypts. The allocation of an exact date of formation to each ring in a ring width sequence is not accomplished. However, sequence segments have been shown to be synchronous and segmental year to year agreement has been demonstrated (e.g. Brookhouse & Brack 2006).

There are relatively few Australian studies which have used fire scars in growth rings of eucalypts to report on fire frequency change (Table 1.1). Brookhouse (2006) has summarised use of eucalypt tree rings for other areas of interest. In the tall wet forests of southern Tasmania two eucalypt regeneration studies were undertaken at the Warra Long Term Ecological Research Site (LTER) (Hickey *et al.* 1999; Alcorn *et al.* 2001). The former study determined the likely fire years of the site by ageing understorey species (Bowling 1954) to approximate stand ages which were then compared with a recorded history of local fires with variable success (Hickey *et al.* 1999). In the later study, tree rings over a 'reliable' radius were counted in old-growth and regrowth *E. obliqua* stumps to approximately age the trees. Approximately 60% of the ring counts were deemed unreliable and estimates for error of around 15% were indicated for the old growth trees (n = 15) (Alcorn *et al.* 2001). Fires were inferred from the age classes. These were three or four between 1600 – 1800 and five or six between 1800 – 2000.

Woodgate *et al.* (1994) estimated a fire history from a stand of *E. sieberi* forest in East Gippsland using 2-3 trees each from three different stand ages. *Eucalyptus sieberi* rings were reported as annual when counted from samples in a nearby forestry coupe containing trees of known age. Ring widths over several radii were measured and growth curves were used to suggest fire years. The concept of false and/or missing rings in each radius cancelling each other out was first reported by Woodgate *et al.* (1994). This is an important concept because other more recent work has reported on the observation of rings on one radius but not on another. For example, this phenomenon was detected when rings were counted in tree species of fire-prone areas which displayed particular growth characteristics such as wedging (e.g. *Sequoia sempervirens* Waring & O'Hara 2006).

Study type	Author/s	Species	Cross-dating	Cross-matching	Ring counts	Forest type and Location
Changed fire regime	Ellis 1985	*E. delegatensis*	N/S	N/S	Aged trees & fire scars	Mixed forest NE Tas
Fire history	Banks 1982	*E. pauciflora*	N/S	Visual, growth pulses	Aged trees & fire scars	Sub-alpine forest A.C.T.
Changed fire frequency	Bowman & Panton 1993	*C. intratropica*	N/S	Visual	Aged trees	Savanna NT
Changed fire frequency	Podger *et al.* 1988	*E. obliqua*	N/S	N/S	Aged trees	Wet forest SW Tas
Fire scar damage	McCaw 1983	*E. marginata*	N/S	N/S	Aged trees	Jarrah forest SW WA
Fire scar formation	McBride & Lewis 1984	*E. miniata*, *E. tetradonta*	N/S	N/S	Aged fire scars	Savanna woodland NT
Stand age and fire	Rayner 1992	*E. diversidolor*	N/S	Visual	Aged trees	Karri forest SW WA
Fire history	Woodgate *et al.* 1994	*E. sieberi*	N/S	Visual, growth pulses	Aged trees & fire scars	Wet eucalypt forest SE Vic
Fire history	Burrows *et al.* 1995	*E. marginata*	N/S	Visual match to known fire history	Aged trees & fire scars	Jarrah forest SW WA
Stand age and fire	Hickey *et al.* 1999	*E. obliqua*	N/S	N/S	Aged fire scars	Wet forest SW Tas
Stand age and fire	Alcorn *et al.* 2001	*E. obliqua*	N/S	N/S	Aged fire scars	Wet forest SW Tas
Hollow formation	Whitford 2002	*E. marginata*	N/S	N/S	Aged trees	Jarrah forest SW WA
Hollow formation	Gibbons *et al.* 2000	*E. obliqua*, *E. fastigata*	N/S	N/S	Aged trees	Wet forest SE Vic/NSW
Hollow formation	Rose 1993	*E. wandoo*, *E. salmonophloia*	N/S	N/S	Aged trees	Jarrah forest SW WA

Table 1.1 Summary of fire research which has used ring counts or visual cross-matching of ring patterns to determine tree age and/or fire scar years. N/S = not stated, SW = southwest, SE = southeast, WA = Western Australia, Tas = Tasmania, Vic = Victoria, NT = Northern Territory, A.C.T. = Australian Capital Territory.

McBride & Lewis (1984) tested the validity of fire history information from fire scars in eucalypts in a controlled experiment in high open-forest and low-open grassy woodland in Kakadu National Park. They determined that fuels, related to season, were a significant factor in determining whether a tree was scarred or not. Early dry season burns were of low intensity due to moist fuels and resulted in few (20%) trees being scarred. Late dry season burns were of high intensity and resulted in most of the trees (90%) being scarred. Fuel accumulation was sufficient to injure trees in both biannual and annual burns. Completeness of fire capture was assured by the 'fortuitous' choice of individual sample trees which totalled five in each of the treatment plots. There were no ring anomalies in the seven years of the study. Caution was exhorted in extrapolation of these results to other areas due to the different nature of fuel and fire behaviour in differing ecosystem types. This study provides evidence that fuel conditions affect low intensity fires with concomitant low incidence of fire scars whereas high intensity fires caused a high incidence of scarring. The capacity for low intensity fires to leave scar evidence in eucalypts is an additional important observation.

1.5 Research aims and thesis outline

'Fire history information is an essential element in describing forest ecosystems, development of resource management alternatives and implementation of programs in fire management planning and operations.' (Arno 1976).

There are no data on the historic occurrence of fire in dry eucalypt forests in Tasmania. An investigation into the history of fire frequency in the dry eucalypt forests and woodlands of the Eastern Tiers and southern Midlands of Tasmania is warranted for several important reasons:

- baseline data provides a foundation on which to build;
- as one component of the fire regime, knowledge of historic fire frequency can be used to compile fire management plans with more confidence;
- knowledge of fire history can inform, and give context to many aspects of ecological and historical research;
- an opportunity is presented to address any gaps with information from other disciplines such as anthropology; and
- inferences on the effects of divergent fire frequency between sites with different land use histories can be made.

This thesis aims to determine, document and interpret past fire occurrence within the Eastern Tiers, Tasmania.

Specifically this study aims to:

1) ascertain the annuality of tree rings from several eucalypt species using dendrochronological techniques;

2) devise innovative ways to use available technology and resources to support the management, arrangement and analyses of data;

3) develop and refine a method for counting tree rings in order to establish, or approximate, a year of formation for each encountered fire scar;

4) account for errors or omissions in the collected data;

5) establish a fire chronology; and

6) suggest possible reasons for temporal and spatial variation in fire frequency.

Chapter 2 describes characteristics of the study area generally and each site in particular. The distribution and physiological characteristics of the studied eucalypts, relevant to detection of fire scars, is covered. The development and implementation of a sampling strategy including site selection, harvesting and preparation are detailed. Observations pertaining to tree ring attributes, fire scar identification, methods related to ring counting, estimation of tree age and the development of fire scar chronologies, from which several subsequent chapters draw reference, are also described in this chapter.

Chapter 3 details a dendrochronological examination of eucalypt tree rings and reports on the usefulness of this method for establishing their annuality. The development of a software program which specifically addresses issues of tree ring data management and analysis is described. This chapter addresses the question: *Will eucalypt rings cross-date?*

Chapter 4 addresses the question of eucalypt tree ring reliability. The chapter incorporates a mini review of methods for testing the accuracy of ring counts and continues to describe the ways in which error estimates are calculated for the fire scar data. This chapter addresses the question: *Are eucalypt rings reliable enough to reconstruct a fire history from ring counts?*

Chapter 5 reports on the detection and elimination of potential sources of error in the construction of fire scar chronologies. The fire scar data are vigorously interrogated and a range of environmental variables are introduced. A method is described which adjusts the fire scar data to account for variability in sample size. This chapter addresses the question: *Can sources of error be avoided or eliminated by adjustment of the fire scar data?*

Chapter 6 presents the fire scar chronologies and explores both temporal and spatial patterns in relation to site similarity and any climatic influence. Distinctly different patterns in the fire scar data are identified and documented. This chapter addresses the question: *What are the temporal and spatial patterns in the fire frequency data?*

Chapter 7 offers cultural and ecological explanations for the patterns identified in the previous chapter. The anthropological, ethnohistorical, ethnographical and historical literature provides a range of possible causes and explanations for the distinct breaks in the fire scar chronologies. This chapter addresses the question: *What are the possible causes for the identified patterns in the fire history?*

Chapter 2

Physical environment and sampling methods

2.1 The Study Area

Tasmania is an island State of Australia. It lies off the south-eastern coast of the mainland between 40^{0} and 44^{0} S and 144^{0} and 149^{0} E (Fig 2.1). The area of the state is approximately 67,000 square kilometres. There are distinct differences in soils, topography, vegetation and climate between the western half of the island and the east (Jackson 1999). The Midlands, despite being in a rain-shadow from both the east and the west, is an agriculturally productive series of valleys stretching from near Launceston in the north to Oatlands in the south (Fig 2.2). The soils of Tasmania are diverse with infertile siliceous soils dominating in the west and more fertile argillaceous soils dominating in the east. The lowland vegetation is influenced by three main factors: soil nutrient status, moisture availability and fire regimes (Jackson 1965; Jackson & Brown 1999; Reid & Potts 1999).

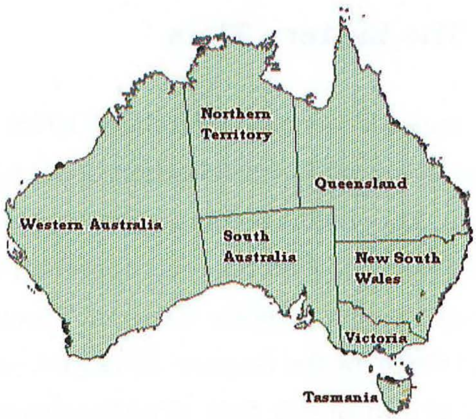


Fig 2.1 Location of Tasmania in relation to mainland Australia.

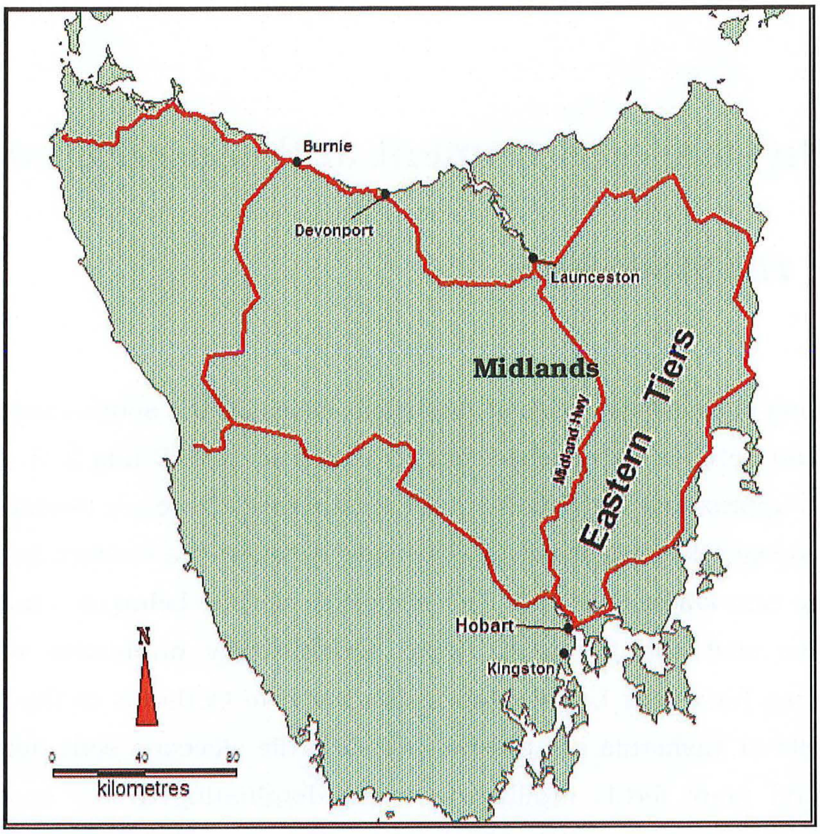


Fig 2.2. Tasmania, showing location of the Eastern Tiers (42°10'S, 147°35'E to 42°30'S, 147°46'E) in relation to the Midlands and the capital city of Hobart. Main road travel routes are depicted in red.

2.1.2 The Eastern Tiers

A botanical regions map for Tasmania (Orchard 1988) utilises natural features to facilitate the mapping of plant distribution and is used by the Tasmanian Herbarium (Fig 2.3). The Eastern Tiers and southern Midlands are together denoted as region 9 (Fig 2.3). This regional approach corresponds almost exactly with the nature conservation regions used by Forestry Tasmania (in Orchard 1988) and Williams (1989) for the Eastern Tiers and southern Midlands which are denoted as region 7 (a and b) (Fig 2.4). For the purposes of this study, the term Eastern Tiers covers the East Coast and the southern Midlands as depicted in the regional approach used by Orchard (1988), Forestry Tasmania (in Orchard 1988) and Williams (1989) and shown in Figs 2.3 and 2.4 below.

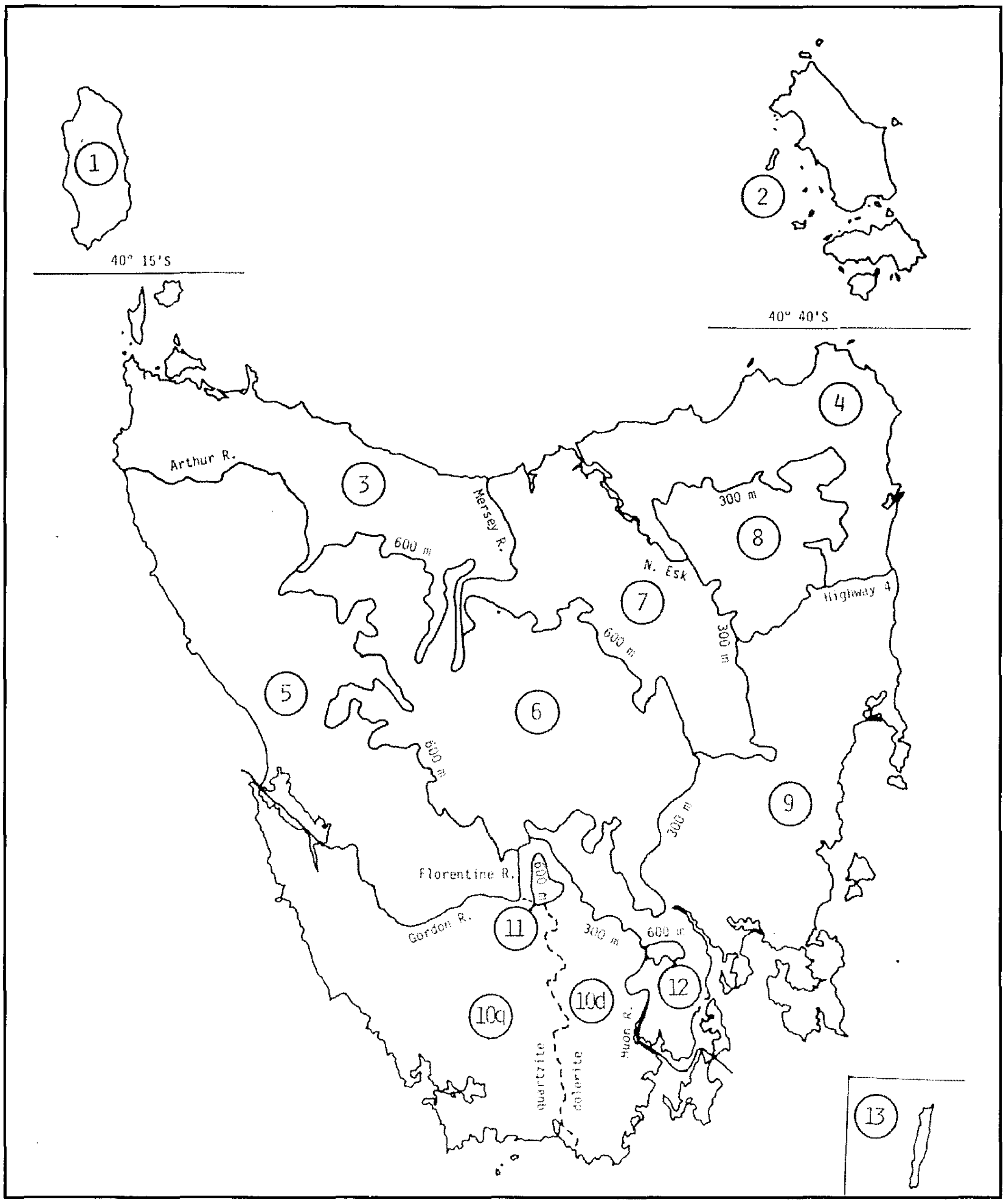


Fig 2.3. Delineation of regions used by the Tasmanian Herbarium (Orchard 1988) showing region 9 which covers the Eastern Tiers and the southern Midlands.

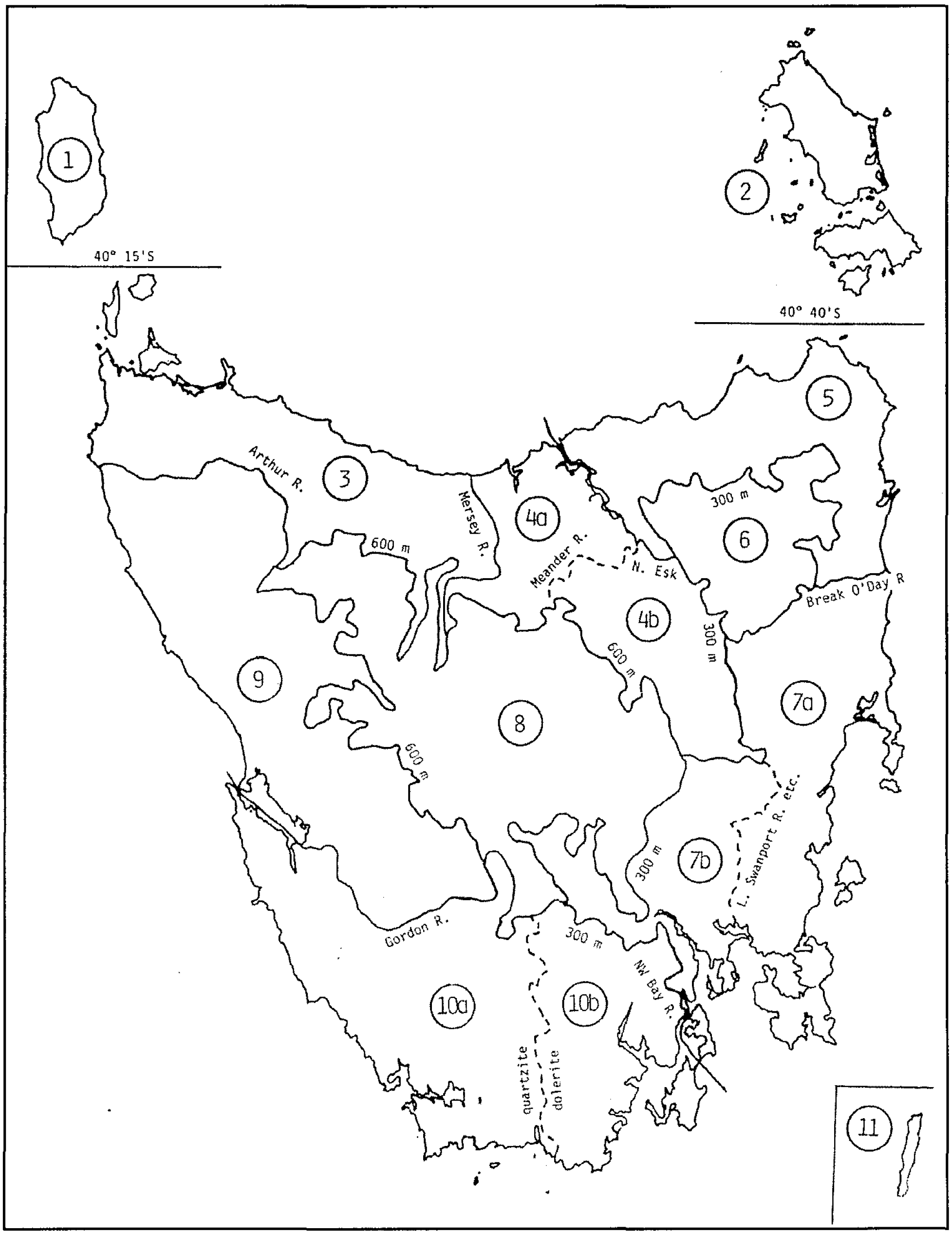


Fig 2.4. Delineation of regions as used by Forestry Tasmania and Williams (1989) showing regions 7 a and b which cover the Eastern Tiers and southern Midlands.

The deeply dissected scarp of the Eastern Tiers rises from coastal plains, which are broad in the south and narrow in the north, to a height of around 700 m forming an undulating plateau before falling away west towards the Midlands. The highest peak is Snow Hill at 971 m. The distribution of rainfall throughout the year in the Eastern Tiers is highly variable with little distinct seasonal variation (Scott 1965). Snow can fall in any month, even down to sea-level but is short lived on the ground. The mean daily winter minimum and maximum temperatures range from 0.9°C – 9.3°C in the northern part of the study area, 2°C – 10.3°C centrally and 2.4°C – 9.7°C in the south. Mean daily summer minimum and maximum temperatures are 8.5°C – 19°C, 8.7°C - 20.2°C and 8.5°C – 18.6°C respectively (Source: Esoclim, McMahon *et al.* 1995).

The effects of aspect are pronounced in mountainous Tasmania with low sun angles and strong north-westerly winds thought to affect moisture availability (Nunez & Kirkpatrick 1980). Lower rainfall and higher temperatures since the late 1970s have increased drought stress in eastern Tasmania (Jackson 1999).

The soils of the Eastern Tiers have largely developed from Jurassic dolerite which, although uncommon in Australia, covers nearly one half of eastern Tasmania. Yellow podzolic soils with a gradational profile commonly form on dolerite (Nicholls & Dimmock 1965) and typify the soils of most of the upland parts of the study area. Relatively infertile podsols form on sandstone and typically support heathy forest. The Eastern Tiers are characterised by a contiguous swathe of scleromorphic vegetation with aspect, slope, altitude and rainfall influencing structure (open-forest, closed-forest and woodland). Treeless vegetation (heath or sedgeland) occurs on the poorly drained soils of the plateau, its persistence, distribution and composition determined by the interaction of fire frequency and drainage (Kirkpatrick *et al.* 1980).

The vegetation of the Eastern Tiers has not been extensively studied although its forests provide a large and valuable timber resource (Duncan *et al.* 1981). In 1971, driven by a burgeoning wood chip industry, large scale, clear-fell commercial logging commenced on both public and private land in the Eastern Tiers. Dry sclerophyll forest is still commercially logged although the clear-fell method followed by very hot slash burning is no longer used. Fire is not always used to burn slash in private operations (L. Reynolds pers. comm. Apr 2004, M. McShane pers. comm. May 2004) although logged public land is systematically burnt to reduce fuel 1-2 years after logging (J. Hickey pers. comm. Jun 2003). Little is known about the vegetation history of the region. Fire history for some communities has been surmised on the basis of current vegetation structure (i.e. even-aged stands) in some areas (e.g. Duncan *et al.* 1981) but is largely unknown for the broader region.

2.1.2.1 Vegetation

The forest types of the Eastern Tiers have been documented from a detailed study which located, mapped and described Tasmanian endemic and threatened species and identified priorities for reservation and management (Kirkpatrick *et al.* 1980). Further work determined that the central East Coast is a centre of local endemism (Kirkpatrick & Brown 1984 a & b). Dry eucalypt forests with shrubby understoreys on dolerite, in particular, support a strong Tasmanian endemic component (Kirkpatrick *et al.* 1980).

Descriptive accounts of the vegetation are few but cover a reasonable range of the study area and comprise: a transect study in the Lake Leake area (Kirkpatrick 1981), a descriptive account of approximately 1000 ha near Lake Tooms (Duncan *et al.* 1981), an experimental regeneration study in relation to forestry operations of the Swanport Block (Duncan 1981) and the documentation of natural resources throughout the highly modified Buckland Army Training Area owned by the Commonwealth of Australia (Wells *et al.* 1977). The following account summarises these works.

Temperate rainforest occurs in disjunct deep, protected gullies and is characterised by *Atherosperma moschatum* with occasional overtopping by *E. delegatensis* and *E. brookerana*. Tall open-forest with closed or open broad-leaved shrub/tree understories (wet eucalypt forest) occurs at medium to high altitudes where fire frequency has been low and is variously dominated *E. delegatensis*, *E. viminalis*, *E. brookerana*, *E. obliqua*, *E. globulus* with either a closed-scrub understorey (*Olearia argophylla*, *Bedfordia salicina*, *Pomaderis apelata*) or an open-scrub understorey (*Acacia dealbata*, sclerophyll and broad-leaved shrubs and graminoids) (Kirkpatrick *et al.* 1980; Kirkpatrick 1981).

The composition of open-forest is highly variable and is largely determined by soil properties, the frequency and intensity of fire and the combination of slope, aspect, topographic position and altitude (Kirkpatrick *et al.* 1980). A rainfall gradient supports a sequence of eucalypts. From dry to moist on dolerite scarps: *E. viminalis-E. pulchella-E. tenuiramis-E. globulus-E. obliqua* and on the dolerite plateau: *E. amygdalina-E. pauciflora-E. viminalis* or *E. dalrympleana-E. delegatensis* (Kirkpatrick *et al.* 1980; Kirkpatrick 1981; Davis 2000). Small areas of low-open forest of the endemic *E. coccifera* occur on exposed ridges at higher altitudes (Duncan *et al.* 1981).

Pure stands of *E. pulchella* and *E. tenuiramis* are primarily confined to ridges in the southeast of the study area (Wells *et al.* 1977) and sandstone substrates are dominated by *E. amygdalina*, *E. globulus*, *E. obliqua* and *E. viminalis*. Cessation of regular, low-intensity fires has been suggested to have resulted in forest development over much of former more open areas (Duncan 1981).

In Tasmania, there are 29 eucalypt species (Curtis & Morris 1975), 15 of which are endemic to the State. There are 16 eucalypt species found in the study area, seven of which were sampled (*) and six of which are Tasmanian endemics (^{e}):

E. sieberi, E. amygdalina^{*e}, *E. pulchella*^{*e}, *E. tenuiramis*^{*e}, *E. viminalis, E. rubida, E. ovata, E. barberi*^{e}, *E. obliqua**, *E. globulus**, *E. dalrympleana**, *E. brookeriana, E. rodwayi*^{e}, *E. delegatensis**, *E. coccifera*^{e}, *E. pauciflora.*

2.1.2.2 Dry sclerophyll forests and woodlands

The vegetation of Tasmania has recently been extensively reviewed (Reid *et al.* 1999). This section describes dry sclerophyll forest composition and distribution status in order to present a brief overview of their significance.

Since eucalypts are the dominant overstorey species in most forests and woodlands the terms wet and dry are used to differentiate between understorey species. Hence dry sclerophyll forests and woodlands in Tasmania are generally characterised by plants which demonstrate scleromorphic characteristics (Duncan 1999). The understorey can be scrubby, heathy, grassy or sedgey and can intergrade over a locality dependent on a range of abiotic factors (Duncan & Brown 1985). Site conditions such as substrate, soil, aspect, insolation, drainage, slope and altitude work synergistically with climate and fire to determine the distribution of dry sclerophyll forests and woodlands (Reid & Potts 1999). For example, near Hobart three dry forest eucalypts on north facing slopes each abruptly occupy a different complex of soils formed on particular substrates: *E. amygdalina* occurs on Triassic sandstone, *E. pulchella* occurs on Jurassic dolerite and *E. tenuiramis* occurs on Permian mudstone. Moisture availability appears to be the main factor in this arrangement (Reid & Potts 1999:209). The survival strategies of individual species determine their response to the fire regime.

The peppermints (subgenus Monocalyptus) cohabit with eucalypts from the gum group (subgenus Symphyomyrtus) in dry sclerophyll forests, and, in mixed species stands, typically dominate. Exploitation of resources in divergent ways (Gill 1981b; Noble 1989) and differing abilities to recover from fire, frost, drought and waterlogging are thought to partially account for this widespread occurrence of community eucalypt diversity (Reid & Potts 1999).

2.1.2.3 Fire

Scleromorphic attributes permit plants to persist in locations where inconsistency in supply or availability of moisture and nutrients occurs (Specht 1981). These are usually fire prone environments where plants, including eucalypts, have also developed characteristics which enable fire by providing fuel. Plant parts such as bark, leaves, twigs and branches are shed (Kozlowski 1973) which, over a relatively short period (3 - 5 years), can accumulate to provide sufficient fuel to carry fire (Dickinson & Kirkpatrick 1987; Bresnehan 2003). The rate of accumulation is dependent on the nature of the understorey, the species and density of eucalypts and the previous fire history, notably time since the last fire. For example, regularly burnt *E. amygdalina* open-forest near Mt. Wellington, Hobart accumulated fuel at a more rapid rate than long unburnt *E. tenuiramis* open-forest in a study of fuel accumulation rates in different dry sclerophyll forests (Bresnehan 2003).

In some upland dry sclerophyll communities, fire exclusion has resulted in impoverished understorey composition and structure due to lack of disturbance or progression from woodland to forest. The accumulation of very high fuel loads primarily consisting of coarse woody debris (pers. obs. Aug 2006) accompanies fire exclusion. Conversely, frequent intense fires have resulted in the introduction of exotic weed species, especially in the ground stratum, and species which are able to persist under such conditions (e.g. *Pteridium esculentum* and *Acacia dealbata*) have been favoured (Duncan & Brown 1995).

2.1.2.4 Fire Weather

Conditions conducive to the spread of fire are pertinent to the entire island of Tasmania and not just the Eastern Tiers. Such conditions occur on average 2 – 3 days, most usually in the summer months (pers comm. Mark Chladil, TFS 11 Jun 2008). However, anomalies can occur. Bushfires burned on the eastern shore of Hobart on an October day in 2006 under temperatures rarely recorded for this time of year. Assuming a source of ignition, the conditions that facilitate bushfire generation and spread are high temperatures, low relative humidity, high wind speeds and wind gusts. It is this combination of conditions which are colloquially characterised as the "bad" fire day.

According to Jackson (1999), using data from Foley (1947) and SES (1990), it is the presence of a high pressure cell, wedged between two low pressure cells, in the Tasman Sea at around latitude 44°S which, when moved by an approaching cold front to the west of Tasmania, can cause the worst "bad" fire day conditions in Tasmania, because hot, dry air from central Australia is forced southwards. This knowledge is important because a high level of predictability in weather forecasting can be provided for Tasmania.

There are no available data for lightning strikes prior to 1998 (TFS unpubl. data 2007). Rainfall data, in particular, years of lower than average rainfall, have been examined in detail in chapter 6. There are no data currently available for trends in the various fire weather indices (pers comm. Mark Chladil, TFS 11 Jun 2008). However, a TFS funded study is currently underway which aims to construct annual and seasonal trends for Tasmanian conditions.

2.2 *The Eucalypts*

Eucalypts are opportunists (Reid & Potts 1999). They are found all over Australia forming approximately 600 species (Brooker & Kleinig 2001).

Aspects pertinent to the present thesis are:

- the eucalypt growth ring; and
- factors influencing susceptibility to fire scarring.

2.2.1 The eucalypt growth ring

Dadswell (1972) examined the ring clarity of some eucalypt species and found a high degree of variability. Of those species used in the current study two were not mentioned and one was highly variable.

E. amygdalina (endemic) a-c = very clear to good clarity
E. dalrympleana a-c = very clear to good clarity - variation within and between
E. delegatensis a-e = very clear to poor clarity – variation within and between
E. obliqua b-e = good to poor clarity
E. globulus b-e = good to poor clarity
E. pulchella (endemic) not mentioned (non-commercial species prior to 1972)
E. tenuiramis (endemic) not mentioned (non-commercial species prior to 1972)

Eucalypt growth rings, when unclear, have been identified by structural aspects such as vessel size and distribution with the use of electroscanning microscopy (Brookhouse 1997) or other forms of magnification (Argent 1995). A successful ring width based chronology was built using *E. obliqua* in the former study and unsuccessful identification of annual growth in *E. camaldulensis* resulted from the latter. The differences in success were not due to the level of microscopy used but arose from the inherently different structural characteristics demonstrated by different eucalypt species (Argent 1995), and, in the case of *E. camaldulensis*, within species (Sesbou & Nepveu 1978 cited in Wilkes 1988). Within-tree variation in growth ring structural characteristics is related to tree age but can vary from 25% to 50% in neighbouring trees of the same species and of the same age (Wilkes 1988) frustrating a uniform approach to the identification of ring boundaries.

That eucalypts produce approximately annual growth, associated with climatic periodicity, has been suggested by Green (1967), Ashton (1975) and Cremer (1975) for temperature and Hopkins (1968), Pook (1985) and Rayner (1992) for precipitation. Hopkins (1968) showed that growth stopped in *E. obliqua*, *E. radiata* and *E. regnans* due to low temperatures in Victoria during winter. Ashton (1975) suggested that environmental factors which initiate growth could be different from environmental factors which initiate semi-dormancy. Probably, it is the combination of moisture and temperature, and associated hormonal responses (Larson 1960), which determines the transition from one type of annual growth to the other resulting in the contrasting bands of early and late wood comprising a growth ring (Zobel & van Buijtenen 1989).

Studies utilising dendrochronology throughout the Americas and Europe all use the term latewood and earlywood to describe the two types of wood laid down by the tree over a single calendar year. Earlywood consists of pale coloured, first formed, thin walled tracheids and vessels formed in the initial period of rapid growth while latewood tracheids are dark coloured, have thick walls and are formed at the end of the growing season. It is usually conifers and deciduous hardwoods to which these terms apply since it is conifers and deciduous hardwoods which are the target species in the northern hemisphere (Fritts 1976, Schweingruber 1989, Cook & Kairukstis 1990). In such trees, the tree ring is usually readily identifiable by a clear boundary due to the cessation in cambial activity at the onset of dormancy. In south-eastern Australia the growing season usually encompasses two calendar years with growth of the pale coloured lightwood (earlywood) commencing in Spring (September – November) and gradually changing to dense darkwood (latewood) growth in late summer, autumn and early winter (Feb – Jun) (Jacobs 1955).

Differences within species occur. Amos *et al.* (1950) found that growth of *E. delegatensis* from the Canberra district changed from the previous years earlywood to latewood throughout autumn and winter, terminating in an abrupt change to earlywood in September. No such clarity was found for the same species examined in Tasmania.

2.2.2 Factors influencing the susceptibility of fire scarring

The formation of a fire scar in the tree bole is the direct result of cambium injury. The degree to which the cambium is injured is dependent upon factors such as fire behaviour about individual trees (Gill *et al.*. 1986), stem diameter (Gill 1974; Burrows 1987; Burrows 1994), flame duration (Gill 1974), pre-fire cambium temperature (Hare 1965; Vines 1968), prior fire injury and bark properties (Gill and Ashton 1968, Vines 1968).

2.2.2.1 Bark properties

Bark thickness and fire resistance is rarely uniform about the bole and in eucalypts is related to species and tree age. Eucalypt bark types demonstrate highly variable fire resistance with early studies reporting that the increasing order of bark flammability matched the increasing response to heat in three eucalypts: *E. cypellocarpa* (gum), *E. radiata* (peppermint), *E. obliqua* (stringybark) (Gill and Ashton 1968; Vines 1968). Reduced bark thickness at the site of a fire injury provides opportunity for further cambium injury with subsequent fires in any eucalypt species. Partial cambium death can occur through radiant heat where the bark splits and lifts from the stem. Charcoal is not an attribute of such scars since heat, not flame, is the cause.

A positive relationship between bark thickness and increasing stem diameter has been well established in North American softwoods and hardwoods (Hare 1965, Hengst and Dawson 1994) and in eucalypts (Gill and Ashton 1968, Grassia 1980, Chatto *et al.*. 2003). In contrast, several Australian studies using eucalypts have reported a tapering off effect where bark thickness ceases to be proportional to girth increase (West 1979, Gill 1980, Burrows 1987).

Some eucalypts, such as Jarrah, *E. marginata* (Burrows 1987), may not record evidence of low intensity fires due to bark protection (Vines 1968). Some thinner barked species, such as *E. pauciflora*, are likely to record even very low intensity fires (Richards 2000). Other eucalypts, regardless of bark type, may form fire scars in low intensity fires depending on fuel conditions (e.g. McBride & Lewis 1984).

A personal observation of fire scar formation in young (< 40 yrs) *E. pulchella* and *E. tenuiramis* from a site near Hobart supported the findings of Richards (2000). A fuel reduction burn in Oct 2004, rated 'low' in intensity (scorch height < 1.5 m), caused lower bole scarring in many trees, but not all, from heat. The bark on all observed trees at the lower bole (thickness 1 cm – 2.2 cm) had buckled and split enabling a scar, or scars, to be seen. Flame scorch was evident only on a single tree. The fuel load was estimated to be ~ 10 t/ha with no break in continuity, was dry on top but had increased moisture with depth. The moistness of the underlying fuels contributed to the low degree of intensity. This observation demonstrates that young trees can develop scarring caused by low intensity fires. However, due to their small size, these scars may be undetectable after many years of growth. The capacity to detect all such scars may depend on sampling height and fire history reconstructions may be incomplete as a result.

2.2.2.2 *Tree age and fuel characteristics*

Trees in a forest stand are not all sufficiently injured to sustain scarring during fire passage. Micro-site conditions, individual tree physiology and previous fire history, proximity of neighbouring trees, landscape location, fuel accumulation, arrangement, condition and distribution, weather and chance determine which trees will sustain injury during a fire. Of these conditions, sustained burning of coarse fuel beneath a tree will increase the likelihood of cambium breaching and injury. Banks (1982) observed a litter halo effect where litter accumulation directly beneath tree crowns increased available fuel. Older trees are more prone to branch shed (Kozlowski 1973; Gibbons *et al.* 2000) and a fuel halo can readily be accumulated in the absence of fire. Reduced bark thickness recovery due to repeated firing (Jacobs 1955, Gill 1974) and high localised litter loads will combine to carry fires of sufficient intensity to produce sub-lethal temperatures which cause partial cambium death. Branch death and shedding, accelerated in burnt trees (Lindenmayer *et al.* 1990), occurs in concert with increasing tree age and natural physiological decline (Marks *et al.* 1986; Lindenmayer *et al.* 1993; Gibbons & Lindenmayer 2003). The halo effect of this type of solid fuel is likely to play a contributing role to the creation of fire scars in older trees.

Although uncommon, eucalypts in the dry forests of Tasmania can reach an estimated age of around 550 yrs (J. Hickey pers. com. Jun 2006). Large, old senescing trees are predisposed to rotting cores especially if fires of sufficient intensity have occurred early in the life of an individual. Access for decay organisms is likely to predispose such trees to rotting (Perry *et al.* 1985) which may preclude a record of fire at the time the tree was young and the nature and extent of rot may affect the record of subsequent fires in very old trees.

2.3 Methods

2.3.1 Site selection

The study area covers 5300 km^2 and is bounded by the Fingal Valley in the north and the Buckland Valley in the south. The Midlands Highway approximates the western boundary and the Tasman Highway, the eastern boundary (Fig 2.5). Thirteen sites were selected which cover the geographical range of dry sclerophyll open-forest and woodlands in this region.

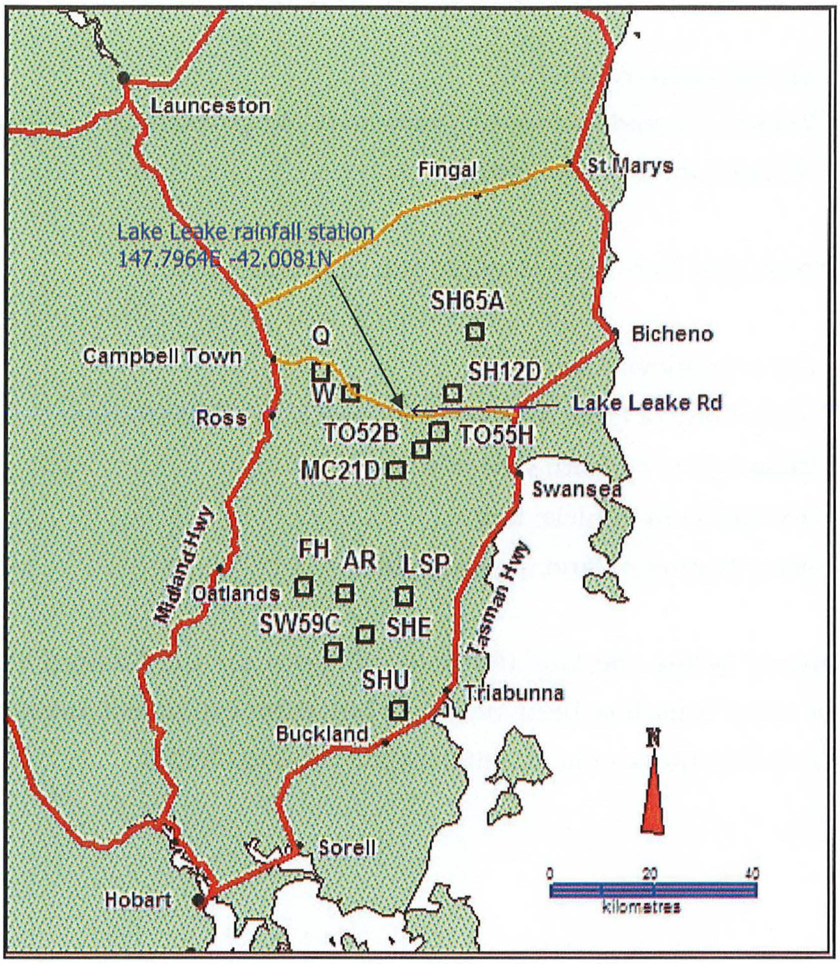


Fig 2.5 Simplified map of eastern Tasmania showing the study sites and boundary of study area: the Fingal valley is the northern border with the Buckland valley bordering the south. The Tasman Highway to the east and the Midland Highway to the west approximate the 300 m contour level.

A single stump is referred to as a sample. All samples are stumps but where appropriate, are referred to in the text as a tree. Forestry operations have been active since the early 1970s and a large number of sites with stumps were available. However, in 2003, no coupes in the dry forests of the Eastern Tiers were available which met all three primary pre-determined criteria:

1) recently harvested,
2) once covered by recently harvested 'old growth' dry forest, and
3) had a known fire history.

The criteria that were used to guide site selection were:

- dry sclerophyll forest;
- availability of large recently (< 30 yrs) harvested stumps;
- known year of death year of trees;
- accessible by vehicle; and
- some history of land use available

Fire history before the late 1990s is unknown for the Eastern Tiers. The exact date of some fires has been recorded but their extent not necessarily mapped, since that date (pers. com. K. Hitchcock FT August 2006).

2.3.1.1 Site climatic data

Temperature and rainfall influence tree growth (Florence 1996) and are therefore important attributes of each site. Temperature and precipitation data were calculated using Esoclim (McMahon *et al.* 1995) and precipitation data for site SH12D were compiled from Lake Leake station (Fig 2.6). Between site variation in mean annual temperature is minimal with the difference being 1.8°C (Table 2.1). However, mean annual precipitation varies considerably with the difference being 249 mm. It is lowest at site MC21D (579 mm) and highest at site SH65A (828 mm) (Table 2.1).

Site	Grid Ref GDA94	Mean annual temperature (C)	Max daily temperature (C) (warmest period)	Min daily temperature (C) (coldest period)	Mean annual rainfall (mm)	Rainfall (wettest period) (mm)	Rainfall (driest period) (mm)
SH65A	0068/3771	9.3	19.9	0.8	828	20	11
Q	9929/5808	9.4	21.5	0	661	17	0
SH12D	5821/1448	9.3	20	0.7	765	18	10
W	6089/1295	9.8	21.6	0.3	617	15	0
TO55H	3387/3444	9	19.7	0.6	749	17	10
TO52B	9767/0630	9	19.8	0.6	710	17	0
MC21D	4891/6179	9.3	20.3	0.6	579	13	0
FH	6953/3576	10.4	21.7	1	584	14	0
AR	3157/1991	10.8	21.8	1.5	620	15	0
LSP	6625/1710	10.3	20.7	1.6	614	15	0
SHE	8889/4190	10.3	20.7	1.6	650	16	0
SW59C	2767/0789	10.3	20.9	1.4	651	16	0
SHU	6088/9275	9.9	19.5	2	756	18	11

Table 2.1 Rainfall and temperature data for each of the 13 sites. The warmest and driest period is between January and March and the coldest and wettest period is between June and August. (Source: Esoclim, McMahon *et al.* 1995)

2.3.2 Sampling

2.3.2.1 Sampling strategy

Of the 13 sites, one was used to sample both young (< 140 yrs) trees and older (> 200 yrs) trees for dendrochronological examination and fire history reconstruction. Older trees (> 160 yrs) were sampled from the twelve other sites. Of these, three were used to collect samples on which to attempt cross-dating. All sites were used for fire history reconstruction (Table 2.2). All trees from all sites bore fire scars.

	Sites												
	SH 65A	Q	SH 12D	W	TO 55H	TO 52B	MC 21D	FH	AR	LSP	SHE	SW 59C	SHU
Dendrochronology (young trees)			x										
Dendrochronology (older trees)	x		x				x					x	
Fire History (older trees)	x	x	x	x	x	x	x	x	x	x	x	x	x

Table 2.2 A breakdown of sites from which the various samples were collected.

The 1) land tenure, 2) community type (Duncan & Brown 1985; Kirkpatrick *et al.* 1995; TASVEG 2006), and 3) known fire history follows. In order of occurrence on a north/south gradient the sites are:

SH65A

1) land tenure

Public land managed by Forestry Tasmania. Snow Hill Forestry Block. Section 65. Coupe number SH65A. Unlikely to have been used for rough sheep grazing.

2) community type

Shrubby *E. amygdalina* forest (DAD). Before 2002, the site had not been commercially logged and comprised an 'old growth' dry forest community of *E. amygdalina* with *E. pulchella* occurring on insolated upper slopes and ridges and *E. obliqua* occurring on gully flanks. *E. dalrympleana* was present as a minor species.

3) known fire history

No records of fire throughout the study site or the immediate vicinity could be located.

Q

1) land tenure

Quorn. Vast private landholding near Campbelltown. The year in which the sampled paddock trees were felled was estimated by the property owner. Sheep breeding and grazing property established in the mid 1800s.

2) community type

Shrubby *E. dalrympleana* forest (DPD) would once have covered the slopes of this site. Islands of remnant eucalypts, which also included *E. pauciflora*, occurred nearby from which it was possible to identify the paddock stumps. Remnant stumps in an improved pasture setting were sampled.

3) known fire history

No records of fire throughout the study site or the immediate vicinity could be located.

SH12D

1) land tenure

Public land managed by Forestry Tasmania. Snow Hill Forestry Block. Section 12. Coupe number SH12D. Unlikely to have been used for rough sheep grazing.

2) community type

Shrubby-heathy *E. obliqua* forest (DOB). Before 2002, the site had not been commercially logged and comprised an 'old growth' *E. obliqua* dry forest community with *E. tenuiramis* and *E. pulchella* occurring on ridges and rocky outcrops. *E. amygdalina* was also present.

3) known fire history

No records of fire throughout the study site or the immediate vicinity could be located.

W

1) land tenure

Windfalls. Private landholding at Windfalls Bridge near Kalangadoo. The year in which the sampled paddock trees were felled was estimated by the property manager based on the establishment of an Aurora transmission easement. Cattle breeding and grazing property established in the late 1800s.

2) community type

Shrubby *E. obliqua-E. dalrympleana* open-forest (DDP) would have earlier covered this site. Islands of remnant eucalypts occurred nearby from which it was possible to identify the paddock stumps. Remnant stumps in an improved pasture setting were sampled.

3) known fire history

No records of fire throughout the study site or the immediate vicinity could be located.

TO55H

1) land tenure

Public land managed by Forestry Tasmania. Tooms Forestry Block. Section 55. Coupe number TO55H. Unlikely to have been used for rough sheep grazing.

2) community type

Shrubby tall *E. delegatensis* open-forest (DDE). Before 2003, the site had not been commercially logged and comprised an 'old growth' *E. delegatensis* dry forest community with *E. obliqua* and *E. amygdalina* as sub-dominants. *Eucalyptus dalrympleana* occurred as a minor species and *E. pulchella* occupied rocky ridges and outcrops.

3) known fire history

No records of fire throughout the study site or the immediate vicinity could be located.

TO52B

1) land tenure

Public land managed by Forestry Tasmania. Tooms Forestry Block. Section 52. Coupe number TO52B. Unlikely to have been used for rough sheep grazing.

2) community type

Shrubby tall *E. delegatensis* forest (DDE). Before 2003, the site had not been commercially logged and comprised an 'old growth' *E. delegatensis* dry forest community with *E. dalrympleana* and *E. amygdalina* widespread throughout the site. *Eucalyptus pulchella* occurred on rocky outcrops with a heathy understorey. *Eucalyptus obliqua* was not recorded from the sampling area.

3) known fire history

No records of fire throughout the study site or the immediate vicinity could be located.

MC21D

1) land tenure

Public land managed by Forestry Tasmania. Mt. Connection Forestry Block. Section 21. Coupe number MC21D. Possibly used for periodic rough grazing between 1880s and 1930s.

2) community type

Shrubby *E. amygdalina* forest (DAD). Before 2002, the site had not been commercially logged and comprised an 'old growth' *E. amygdalina* dry forest community with *E. dalrympleana/E. viminalis* widely dispersed throughout the site. *Eucalyptus globulus* occurred on gully margins and on east facing slopes.

3) known fire history

No records of fire throughout the study site or the immediate vicinity could be located.

FH

1) land tenure

Font Hill. Private landholding near Lemont, via Oatlands. The year in which the sampled trees were felled was estimated by the property owner based on the establishment of a track through the site. Sheep grazing had occurred since the mid 1850s.

2) community type

Grassy-sedgey *E. globulus/E. viminalis* open-woodland (DGL) currently under a conservation covenant. Logging had previously occurred in the 1970s. The sampling site was at the base of Murderers Tier.

3) known fire history

No records of fire throughout the study site or the immediate vicinity could be located.

AR

1) land tenure

Private landholding near Lemont, via Oatlands. The large site had recently been purchased for the purpose of logging its vast resource of eucalypts which was underway during sampling. The sampling site is the largest at >200 ha and supports several communities.

2) community type

Grassy *E. pulchella* open-forest (DPU) on upper slopes and ridges with *E. viminalis* as a sub-dominant, grassy *E. amygdalina* woodland (DAD) on saddles graded into sedgey *E. ovata* woodland (DOV) in drainage depressions. *Eucalyptus globulus* occurred on east facing slopes and gully flanks. No information was available regarding earlier harvesting and few old stumps were found throughout the site. This suggests that the site had not been cut-over for some time with fire and bio-deterioration serving to obliterate any early evidence of harvesting.

3) known fire history

The logging contractor recollected a fire in ~1976.

LSP

1) land tenure

Little Swanport Nature Reserve adjacent the northern end of the Buckland Military Training Area. Regenerating landscape after selective logging throughout the 1960s and 1970s. Sample (tree) death dates were estimated based on the recollections of a previous landholder and identified from remnant bark and proximity of neighbouring trees.

2) community type

The site consists of very variable topography supporting a range of dry communities: *E. amygdalina* open-forest (DAD) and grassy *E. pulchella* open-forest (DPU) were variously associated with *E. globulus, E. viminalis* and *E. ovata.*

3) known fire history

Neither the current nor an earlier landholder could recollect a fire throughout the study site or in the immediate vicinity before the sampled trees were cut.

SHE

1) land tenure

Stonehenge. Private landholding in the Little Swanport River headwaters catchment. The site has been used for rough sheep grazing for over one hundred years.

2) community type

Grassy *E. globulus-E. viminalis* (DGL) open-forest which had been selectively logged several months prior to sampling. A fuel reduction burn was not planned. Co-occurring eucalypts were *E. amygdalina* and *E. pulchella.*

3) known fire history

No records of fire throughout the study site or the immediate vicinity could be located.

SW59C

1) land tenure

Public land managed by Forestry Tasmania. Swanport Forestry Block. Section 59. Coupe number SW59C. Public land managed by Forestry Tasmania. The private lease for this site was cancelled in the late 1990s.Before then it had been used for rough grazing from the late 19th century.

2) community type

Heathy *E. amygdalina* open-forest on sandstone (DAS). Before 2004, the site had not been commercially logged and comprised an 'old growth' *E. amygdalina* dry forest community with *E. globulus* and *E. viminalis* widely dispersed throughout.

3) known fire history

A neighbouring landholder recollected an escaped fuel-reduction burn in 1978 from a nearby forestry operation moving into SW59C which, at the time, was leased for sheep grazing. There are no other records of fire for the study site or the immediate vicinity.

SHU

1) land tenure

Stonehurst. Vast private landholding via Buckland. The hills where sampling was undertaken were successively ringbarked in the early 1900s, the 1960s and finally in the 1970s. Grazing has been the main land use since the early 20th century. Regeneration has been occurring since the 1980s.

2) community type

Grassy *E. pulchella* open-forest and woodland (DPU) with *E. globulus* occurring as a sub-dominant on east facing slopes and gullies. *Eucalyptus amygdalina* was locally dominant.

3) known fire history

No records of fire throughout the study site or the immediate vicinity could be located.

Data collected from each tree (n), summarised in Table 2.3, were:

- AGD grid location of each stump – using a global positioning system (gps)
- position in landscape (ridgetop=A, midslope=B, other e.g. drainage depression edge=C)
- species
- diameter over bark (dob)
- stump height (mm)
- bark thickness (mm)

Environmental attributes collected from each site were:

- slope using a clinometer
- aspect using a compass
- geological type (e.g. dolerite, sandstone)
- observable vascular plant species
- harvest date
- altitude calculated from the relevent 1:25,000 topographic map

Site	n trees	Area (ha)	Altitude (m)	Dominant eucalypts	Forest type	Substrate	Mean annual rainfall (mm)*
SH65A	7	12.2	562	*E. amygdalina*	Open-forest	Dolerite	828
Q	11	14.5	504	*E. dalrympleana/E. viminalis*	Pasture (Open-forest)	Dolerite	660
SH12D	7	42.1	471	*E. tenuiramis/E. obliqua*	Open-forest	Dolerite	765
W	5	1	541	*E. dalrympleana*	Pasture (Tall open-forest)	Dolerite	617
TO55H	7	15.1	571	*E. delegatensis*	Tall open-forest	Dolerite	748
TO52B	10	17.4	660	*E. delegatensis*	Tall open-forest	Dolerite	708
MC21D	5	3.5	573	*E. obliqua/E. amygdalina*	Open-forest	Dolerite	579
FH	5	.2	448	*E. globulus/E. viminalis*	Woodland	Dolerite	585
AR	12	208	382	*E. amygdalina/E. pulchella*	Woodland	Dolerite	621
LSP	10	61.5	219	*E. amygdalina/E. obliqua/E. globulus*	Open-forest	Dolerite	613
SHE	8	1.5	365	*E. globulus/E. amygdalina*	Open-forest	Dolerite	647
SW59C	9	19	261	*E. amygdalina/E. obliqua*	Open-forest	Sandstone	649
SHU	8	102.6	236	*E. amygdalina/E. pulchella*	Open-forest	Dolerite	755

Table 2.3. Study site attributes.*Source: Esoclim.

The following sections describe the methods used which produced the data used in the following chapters. Additional methods are described separately, in the relevant chapter. It should be noted that different sample numbers were used for the various analyses. Sample size for each analysis is denoted as (n = *x*) and appears in the relevant methods and/or results sections throughout the thesis.

2.3.2.2 Sample selection

The use of the range of eucalypt species occurring on a site is likely to increase the chances of fire detection, although noise related to differences in susceptibility to fire scarring could be included in the data. All samples were harvested in the same manner and, except for the older trees at SH12D, a range of species was sampled from each site (Table 2.4).

	Sites												
Species	SH 65A	Q	SH 12D	W	TO 55H	TO 52B	MC 21D	FH	AR	LSP	SHE	SW 59C	SHU
E. tenuiramis			O (7) y (8)										
E. amygdalina	O (5)				O (3)	O (1)	O (4)		O (4)	O (8)	O (1)	O (2)	O (6)
E. globulus	O (1)						O (1)	O (5)	O (6)	O (1)	O (7)	O (2)	O (1)
E. delegatensis						O (8)							
E. dalrympleana		O (11)		O (5)		O (1)							
E. obliqua	O (1)		y (5)		O (4)							O (5)	
E. pulchella			y (2)						O (2)	O (1)			O (1)

Table 2.4 Number of individuals (n), and species harvested from each site. O = older trees, y = young trees.

The *young* tree samples (n = 15) were subjectively chosen based on criteria of location in the landscape (i.e. gullies were avoided because of the potentially complacent effect on ringwidths due to the influences of moisture and reduced insolation), the presence of obvious fire scarring and manageable size (diameter >

250 mm in order to fit on the measuring device). Fifteen stumps covering two distinct topographic zones were selected. The topographic zones were: a) a shallow saddle with a southwesterly aspect, and b) an southeast-facing midslope (Fig 2.6).

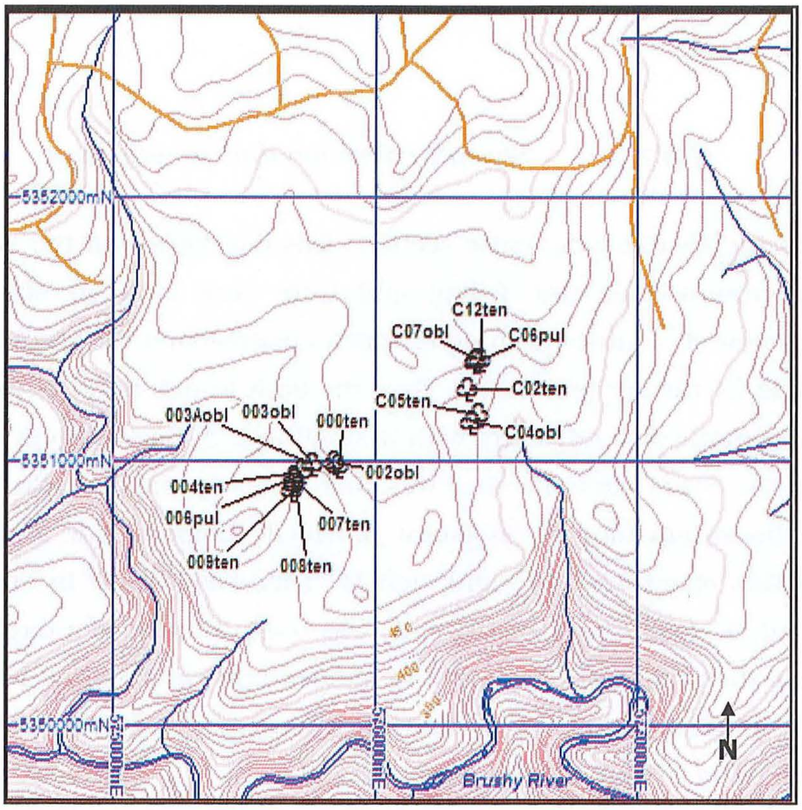


Fig 2.6 Site SH12D with individual samples of 15 young trees in the two different environmental zones.

The *older* trees (n = 104) were subjectively chosen based on the same criteria except that large size and, where possible, sound centres were desirable in order to capture fire scars back in time as far as possible.

Following Banks (pers. comm. 2003) a minimum of five stumps per site was considered adequate. Whole cross-sections from sites covering the environmental and geographic range of the study area were secured. Stumps were selected to be distributed throughout each site. Repeatedly scarred stumps were specifically targeted (Agee 1996). Stumps of suitable size and condition were not found to be common in the study area.

2.3.2.3 Sample collection and preparation

A technique for removing cross-sections was developed. All the stumps were left in the ground after tree felling and were very large in size requiring the development of a cutting technique which ensured that the resulting surface was amenable for further processing. First the bark (rough-barked species only) from the top ~20 cm was cut away with a small axe. A thin (2-5 cm deep) guide cut around the entire circumference was then made in the de-barked zone 5–10 cm below the stump top. An assistant provided chainsaw bar levelling correction during this operation, via hand signals. This was critical in ensuring an even guide cut. A small chainsaw (16" bar) was used. The bar of a large chainsaw (36" bar) was then placed in the cut and, guided and corrected by hand-signals, the operator worked backwards around the stump, ensuring the chainsaw nose was maintained in a level position with the guide cut. In a circular fashion, the cut progressed around the stump deeper and deeper until the cut was complete. The resulting slice provided a clean, workable surface free, or nearly so, of chainsaw scarfing. Scarfing refers to those areas over the stump surface which are uneven, ledged, stepped, rippled or otherwise unworkable and is the natural result from chainsaw use on large trees. Operator posture (operator weight on the machine places upward pressure on the nose causing a meander), sharp chain teeth and even bar groove pressure were important to achieve a successful outcome.

Whole cross-sections from sites SH12D, SH65A, MC21D, SW59C (n=27) were returned to the lab within 24 hours. They were planed and sanded using progressively finer grades of paper (40-1000 grit). Cross-sections were professionally photographed immediately upon completion of sanding since they split, cracked and bowed within three days of removal. High resolution scanning (3600dpi) of the photographic negatives into a desk top photographic program Adobe Photoshop CS resulted in a permanent, fine-grade record of each whole cross-section.

Data were collected in situ from sites TO52B, TO55H, MC21D, W, Q, SHU, FH, SHE, LSP, AR (n=77). A clean surface was created with the chainsaw. Up to four radii (1-4) were chosen away from fire scars (Mutch & Swetnam 1995) and compression wood. A hand plane was used to smooth a route from bark to pith, or to the inner-most ring where centre rot was present. An area between each fire scar and the nearest radius was also planed to the degree necessary to make the ring clear. A mist spray of water was applied and re-applied when necessary; ring clarity was thus enhanced (Mucha 1979; Alcorn *et al.* 2001). Trees were either recently harvested, in which case sapwood was complete or had been killed for some time, in which case sapwood was reduced. In the latter event sapwood rings were estimated from remnant patches on each stump.

2.3.3 Identification of tree rings

2.3.3.1 Ring boundary identification

The growth produced by all seven eucalypts was macroscopically distinct in that sequential bands of light coloured 'earlywood' with high frequency of vessels and dark coloured 'latewood' with low frequency of vessels was observed.

Young trees. Use of a simple desk mounted swing-arm magnifier (x 4 and x 8) enabled the surface of each young tree sample to be examined. Each ring which traversed the entire surface was pencil marked with a short dash. Each ring boundary was traced from radius to radius and cross-checked. Decade rings were marked with a long dash. If a ring did not traverse the entire surface it was deemed suspect and marked accordingly. Apparent, or partial, false rings were noted in this fashion. Two samples were discarded during this process due to severely compressed wood over most of the surface which rendered ring identification impossible.

Sample measurement was carried out using a Lintab 4 measuring stage and TSAPWin (Rinntech 2001). Under the microscope, ring boundaries were determined in accordance with established methods (Stokes & Smiley 1968; Schweingruber 1989) because, working from the bark to the pith, the darkwood/lightwood (latewood/earlywood) boundary provided the most consistent clarity. Each sample was also measured using the 'reverse latewood' boundary (Brookhouse 1997, 2006b). However, an inability to maintain consistency and the frequent lack of boundary (earlywood/latewood) clarity on the samples despite the use of magnification resulted in abandonment of this method.

Ring boundary criteria (Fig 2.7):

Colour change matched with vessel size reduction
Absence of visible vessels co-incident with colour change

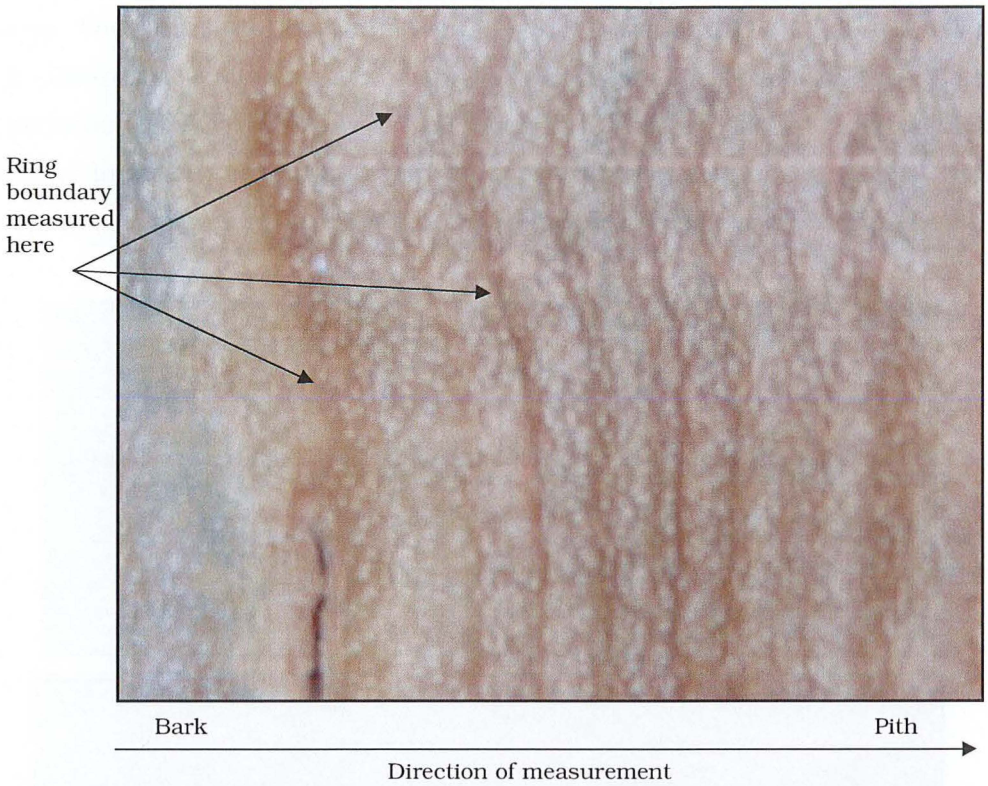


Fig 2.7 Vessel size reduction co-incident with colour change from early to latewood.

Latewood/earlywood ring boundaries were occasionally locally or entirely obscure. Since samples were small, manageable and mostly complete, the whole surface was available for scrutiny. Locally obscure boundaries were clarified by tracing the ring to another part of the sample where the ring boundary became clear. Entire obscure boundaries were consistently determined by increasing magnification and defining the point at which vessel openings ceased. From time to time, this resulted in very small bands of latewood being attributed to the subsequent ring. Overall, ring boundaries were of the highest and most consistent clarity on *E. tenuiramis* and *E. pulchella* and least clear on *E. obliqua*. Stumps of young trees of *E. amygdalina* of suitable size containing fire scars were not located.

Older trees. Ring boundaries were determined visually, without the aid of magnification. All species demonstrated sequential, contrasting light and dark coloured bands. Growth period colour change, latewood into earlywood, provided the cleanest boundaries. Where a ring boundary was indistinct on a radius it was usually possible to follow a ring until a clearer latewood/earlywood boundary was located. The large samples were prepared in the same way as the small ones. Ring clarity was particularly good for *E. amygdalina* (Fig 2.8) and *E. globulus* (Fig 2.9).

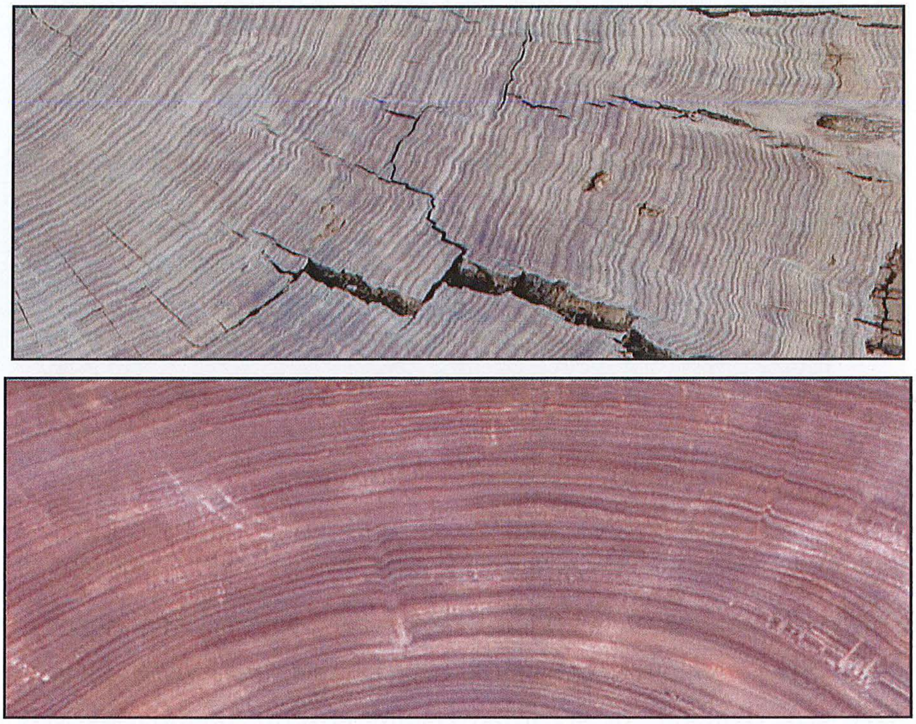


Fig 2.8 Ring clarity for *E. amygdalina* – top = exceptional, bottom = typical.

Once sanded, the pieces were immediately photographed either whole or in two sections depending on size. A high quality camera wielded by a professional photographer was used to take large format photographs (5" x 4") of the large samples. Photographic negatives were scanned from a desktop scanner at 3600 dpi. Those samples which were photographed in two sections were 'stitched' together using the stitch component of a commercially available photographic manipulation program (ACDSee 2001) resulting in a single, albeit very large, photograph (Fig 2.9).

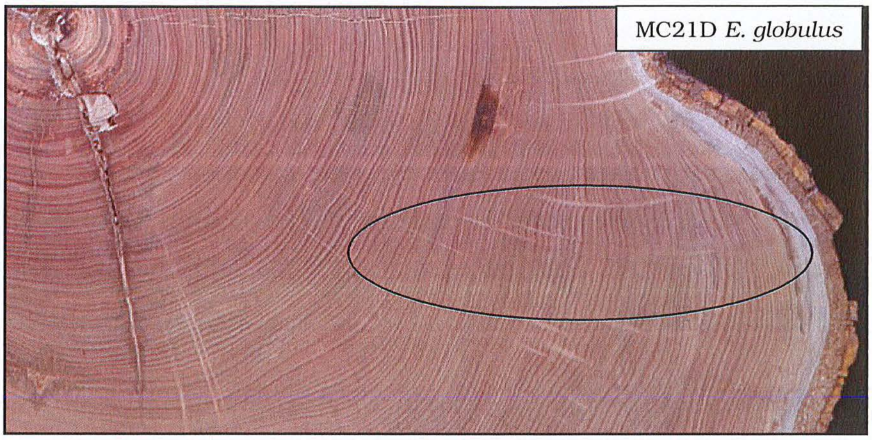


Fig. 2.9 The horizontal stitch line is evident through the middle of the circled area as a colour change. The stitch is relatively seamless because the high resolution of the scanned negative provided quality pixel to pixel alignment. There is no evidence of compromised ring continuity.

2.3.3.2 *Allocation of a calendar year to latewood*

All sites were harvested between January 2003 - April 2004. The young trees were measured from the cambium and a single ring comprised the first band of latewood with the subsequent band of earlywood (latewood of 2002 and earlywood of 2001). This covered the entire growing season. Measuring in this way however, provides a dilemma for ascribing a ring to a particular calendar year since the growing season covers two. Therefore latewood, as the concluding annual growth cycle component, has been used throughout this thesis to designate the ring year. This differs from the traditional use of year of growth commencement as the allocated calendar year. In Tasmania, fires are more likely to occur in late summer. Thus, if the cambium is heat affected, the formation of latewood is likely to be distinctively interrupted. Latewood in *E. globulus* has been shown to form in late summer and autumn when moisture is a potentially limiting factor (Ferraz 1980).

Several samples had missing centre rings due to rot. No attempt to account for these missing rings was made in the small trees. Ages of the older samples are accounted for in Chapter 5. Series for the young trees and large trees from sites SH65A and MC21D therefore commence at the cambium in 2002 and for the large trees from SW59C they commence at 2003 and continue for the length of the available sequence.

Rings were sometimes obscured in the sapwood due to small size. In some cases (3 samples) it was necessary to estimate a count of sapwood rings and measure from the first clear heartwood band of latewood for the young trees. Sapwood rings were also occasionally difficult to identify from the photographs.

2.3.4 Identification of the fire scar

Fire scars were visually identified by the presence of an inclusion embedded in the wood and exposed on the stump surface in cross-section or as an occlusion in the outer sections of the tree bole. Richards (2000: 3-15) provides a detailed description of fire scar formation in eucalypts.

There are several scar characteristics known to result from fire. The presence of a band of bleached or yellowed wood immediately behind a scar (Fig 2.10) corresponds accurately to the width of cambium injury and in depth, to the living sapwood at the time of injury (McCaw 1983) indicating cambium exposure to sub-lethal temperatures (Gill 1974, Banks 1982).

Fig. 2.10 Bleached wood (previously sap at the time of fire) verifies the cause of the scar as fire.

A pattern of rot, similar to the bleached zone described above, is commonly limited to the zone of dead sapwood immediately behind the fire scar. The rot spreads in the direction of the pith (McCaw 1983) and, in the present study, was observed to move outwards beyond the ring in which the injury had occurred usually where extensive heartwood rot was present in long dead stumps. Such a decay pattern is characteristic of scarring by fire (Perry *et al.* 1985) (Fig. 2.11).

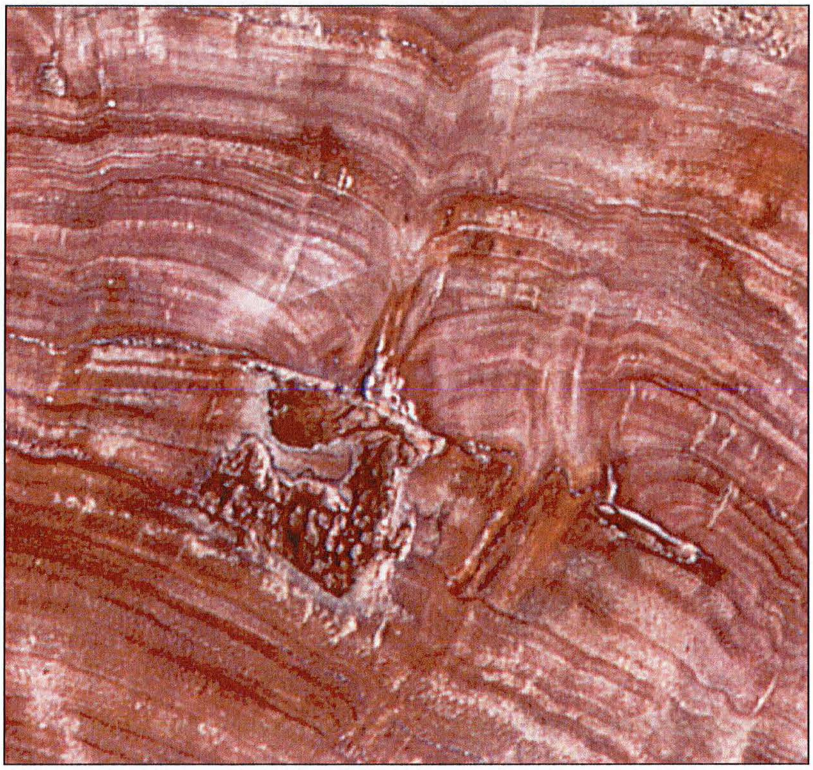


Fig 2.11 Characteristic pattern of rot movement after fire. Spread is toward the pith.

Kino is commonly formed in association with cambium injury (Skene 1965) although some species (e.g. *E. obliqua*) are more prone to this type of response than others (e.g. *E. globulus*). Kino can be predominantly formed in the phloem (subgenus *Symphyomyrtus* species) and in the xylem (subgenus Monocalyptus) (Tippett 1986). Because kino is formed in response to any injury type, its use as a fire indicator is limited. Kino presence was noted but not used as confirmation of fire passage unless it occurred co-incident with other features.

Where successive fires had degraded an occlusion, it was possible to determine the fire year ring, close to the injury site, by using a combination of ring characteristics:

- small rings followed by wider rings grown after the fire;
- yellow, lustrous earlywood;
- an exceptionally narrow ring;
- the fire year ring had a weathered look and frequently undulated for a short stretch either side of the scar; and
- presence of kino in conjunction with one or more of the above.

Discontinuity in tree rings has been shown to occur in Oak (*Quercus* spp.) from northeastern USA (Jordan 1966) and Larch (*Larix* spp.) from the Evenkia region in Russia (Kharuk *et al.* 2005) due to fire. When counting tree rings to determine the age of a fire scar, it is helpful to have a whole cross-section available to trace, as far as possible, the ring around the entire circumference to determine its authenticity and to ensure that it is counted on each radius. Knowledge of the physiological response of the species to fire, such as has been identified for the genera mentioned above, is helpful in accounting for ring anomalies. Eucalypts put on occlusion wood at the site of a fire scar (Jacobs 1955; Gill 1974), expediting the healing process, but confusing the ring counts if they are undertaken in the vicinity of a fire scar because these rings are rarely continuous away from the scar (Banks 1982). For this reason, ring counts, where possible, were undertaken away from the fire scar zone.

2.3.5 Counting tree rings

2.3.5.1 *Radial ring counts*

Ring counting began from the first visible band of latewood in the sapwood. For stumps in forestry operations (sites SH12D, SH65A, SW59C, MC21D, TO55H, TO52B, AR, SHE) the first year was usually the year preceding tree death because tree death occurred in summer or autumn except for site SHE which was logged in spring (Table 2.5). After surface cleaning, earlywood growth of the previous year was visible adjacent to the cambium indicating the current years' latewood growth had not yet formed or was not visible without the aid of magnification. This is consistent with the formation of latewood occurring primarily in autumn/winter (Zobel & van Buijtenen 1989). The year and season of tree death was known for the commercially logged sites and was estimated based on landholder records and recollections for the others. Tree death dates varied at site W (1995 n=2, 1983 n=3).

Sites	TO52B	TO55H	MC21D	SH12D	SH65A	W	Q	SHE	SW59C	LSP	AR	FH	SHU
Tree death (yr)	Mar 2003	April 2003	May 2003	Jan 2003	Mar 2004	1995 1983	Aut 1983	Oct 2004	May 2004	Aut 1978	Feb 2005	1999	1971
First ring at cambium (yr)	2002	2002	2002	2002	2003	1994 1982	1982	2004	2003	1977	2004	1998	1970
Source	F*	F	F	F	F	L*	L	F	F	PL*	F	L	L
Estimated no. of sapwood rings	Nil	Nil	Nil	Nil	Nil	Nil/9	9	Nil	Nil	11	Nil	Nil	11

Table 2.5 Ring counting attributes. *F = Forestry operations, L = landholder records, PL = previous landholder recollections

Ring counts were made to the inner most visible ring along each radius. The absence of inner rings due to obscurity, early fires or rot were accounted for by use of the following method (Alcorn *et al.* 2001; Whitford 2002). The centre ring was visually estimated and a marker placed in the rotted material. Where the centre was hollow, an assistant maintained the marker position. The distance between the inner most visible ring and the marked centre ring was measured and this distance placed back along the radius. The number of rings counted over this distance was added to the number of rings derived from the radius count. Thus an entire, albeit approximate, ring count could be estimated for each radius (Table 2.6). Of the 104 trees, 66% were missing centre rings.

2.3.5.2 Estimation of tree age

Within stump radius ring counts (2 – 5 per stump) were averaged to approximate tree age. This method fails to account for ring width variability about the stump surface over the measured distance back along the radius. Nevertheless, the total rings per radius, shown in the example of the forest veteran over 500 years (Table 2.6), arrive to within 30 rings of each other. This approximation has previously been considered acceptable for the genus *Eucalyptus* over a similar time frame (Banks 1990b).

Radius (Sample TO55H1)	Ring count: cambium to inner most visible ring	Distance to centre ring (mm)	No. of rings over this distance	Total rings per radius
1	486	63	100	586
2	506	60	50	556
3	482	90	85	567
Average age of tree				**570**
Approx. year of establishment (outer ring = 2002)				**1432**

Table 2.6 Divergent ring counts back along each radius over similar measured distances, such as radii one and two above, reflects the wide variability of within ring width about the stump surface.

Stumps were characterised by attribute variability (Table 2.7).

Site	n trees	Approximate period Spanned[1]	Period length (yrs)	Tree age (yrs)		Av. DOB (mm)[2]		Bark thickness (mm)	
				mean	range	mean	range	mean	range
SH65A	7	1715-2002	287	228	152-287	1157	950-1500	24	15-30
SH12D	7	1752-2002	250	237	211-273	1173	1000-1400	20	10-30
TO55H	7	1432-2002	570	293	120-570	1003	770-1300	31	16-55
TO52B	10	1722-2002	280	195	150-280	1293	810-1800	33	15-55
MC21D	5	1767-2002	235	172	138-228	1124	650-1000	24	18-30
W	5	1687-1993	306	231	160-290	1772	1180-2300	-[3]	-
Q	11	1707-1982	275	220	188-275	1528	1030-2000	-	-
SHE	8	1772-2003	231	162	138-238	1234	1050-1510	38	25-46
SW59C	9	1776-2003	227	186	150-227	1267	1000-1650	17	8-25
LSP	10	1722-1976	254	176	114-255	1262	910-1880	-	-
AR	12	1756-2004	248	180	112-227	1332	850-2050	33	18-70
FH	5	1850-1997	147	120	99-135	1238	1000-1480	29	18-40
SHU	8	1699-1970	271	190	140-240	1309	1020-1600	-	-

Table 2.7 Summary of stump attributes including estimated tree age. Note that the sampling height varied between 450 and 1000 mm. [1] = composite length of record from earliest ring of oldest tree to most recent death date. [2]DOB = diameter over bark. [3] bark was either absent or reduced due to weathering from exposure on non forestry sites.

Stumps measuring in excess of 3.5 m in diameter were located at several sites. However, their early fire record was completely obliterated by tree hollowing from successive fires (Fig 2.12).

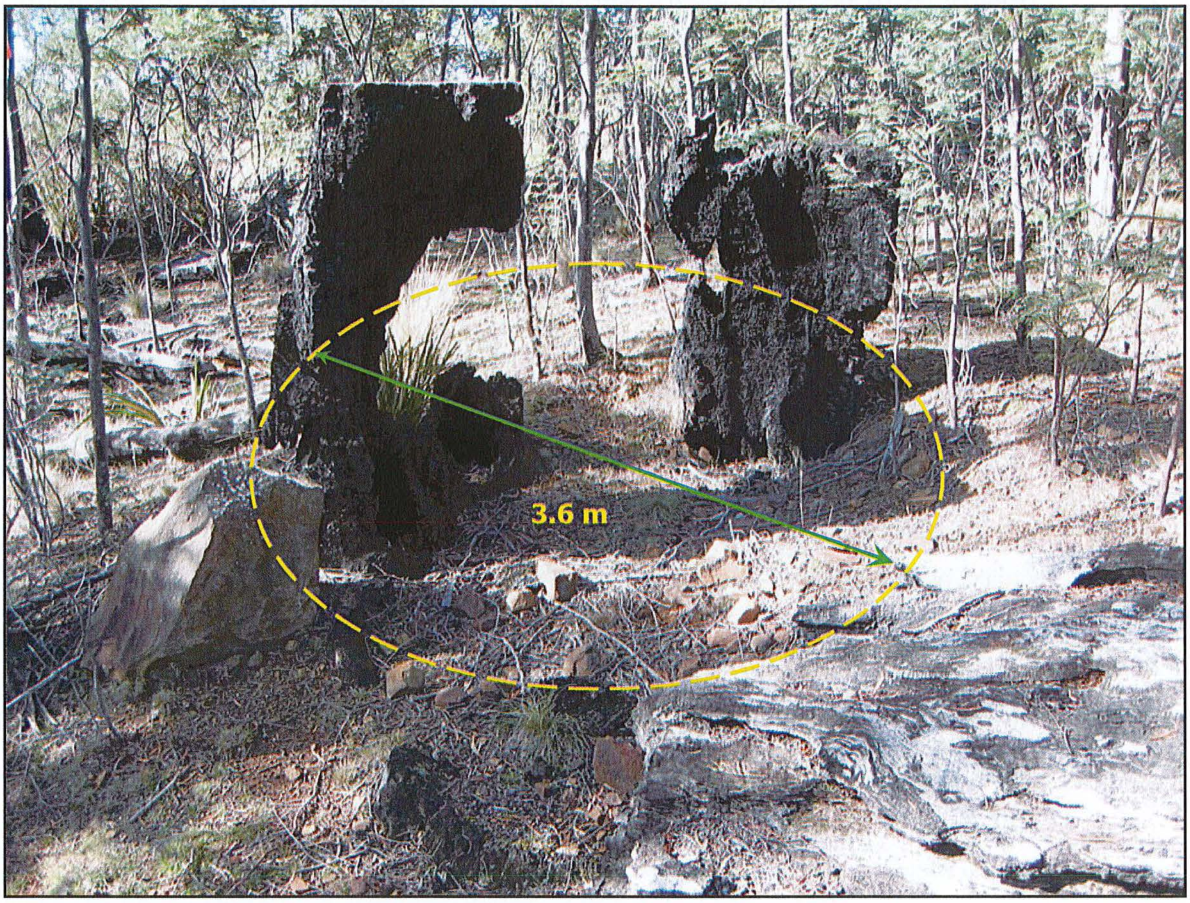


Fig 2.12 Burnt out stump with raised root rocks permits an estimate of diameter. Subsequent fires have completely obliterated the evidence of earlier fires.

2.3.6 Development of fire scar chronologies

2.3.6.1 The individual tree fire scar chronology

Calendar dates were allocated to counted tree rings on each radius to facilitate data management and analysis. This procedure is consistent with other work of this nature using a chronological sequence (Arno & Sneck 1977). No date is presumed to be exact. Scars were dated corresponding to the ring year on each radius. Stumps carried either single or multiple scars from the same fire.

For the young trees at site SH12D, each fire scar was first allocated a date according to the corresponding year on the closest radius in the initial pencil marking exercise. The same fire scar was sometimes allocated different dates from two radii. This resulted from two areas of difficulty: 1) designating ring boundaries under the microscope was not always straightforward due to indistinct growth zones; and, 2) the area in the vicinity of the occluding scar was frequently obscured by rot requiring an estimation of the fire scar ring if other fire scar characteristics, such as discolouration and kino, were absent. Fuel accumulation in *E. tenuiramis/E. obliqua* dry forest is reportedly insufficient to carry a fire under ~4 years (Dickinson & Kirkpatrick 1987; Bresnehan 2003). Consequently, fires at a 1 – 3 year interval should not occur in these forests. The same fire scar dated from different radii or estimated on one radius due to surrounding ring obscurity, was ultimately dated based on the frequency of the most likely candidate date throughout the site (Wagener 1961). No difference in dates generated from different radii were greater than ± 3 years for the small trees. Sequential scars on the one sample confirmed the passage of two distinct fires in relatively close succession. For example, one sample (c12ten) carried separate, sequential fire scars five years apart from ~1934 and ~1939 and again from ~1961 and ~1966.

It was not possible to mark and trace each ring around the entire surface of the older trees as was accomplished with the young trees. The within sample dating of fire scars in the older trees was accomplished by tracing the ring of scar formation to the nearest radius and recording the corresponding date. When the same procedure was undertaken from the same scar to another radius, the date was often different. Number of radii used to generate a fire scar year varied from 1 – 4. When a date for the same fire scar differed by > 20 years the radius was discarded. Dates from remaining radii for the same fire were grouped and averaged using the rule structure of Madany *et al.* (1982) unless two dates were the same. In this instance, the fire scar year was represented with greater confidence. In some instances, dates over two radii recorded same/similar years while the another two radii recorded different but same/similar years for the same fire scar. In this case, all four were averaged. Occasionally it was obvious from the fire scar dates on other trees that the mean date from one couple of years was the likeliest candidate year. All other fire scar dates from separate radii which differed were combined and an average date was recorded for the fire scar. Where, due to surface obscurity, a fire scar date was derived from a single radius only, no adjustments were made. Each set of dates for each fire scar were clearly defined during the calculation process. Known fire years were available for two sites. One landholder (site AR) for example, recollected a fire in 1976. Subsequently, on those samples that carried them, fire scars from this site dated to the mid 1970s were adjusted to 1976.

2.3.6.2 The composite site fire scar chronology

Once each fire scar was allocated a date an individual tree chronology was the result. From here it was necessary to develop a site fire scar chronology.

Eucalypt growth rings are known for their anomalous zones and prevalence of missing or false rings (Mucha 1979; Ogden 1981; Banks 1982; Schweingruber 1992) which, when counted over separate radii, can differ. Wagener (1961) reviewed the problems associated with consolidation of between-tree fire year variation derived from ring counts across a site. He stated that the best solution to this problem was to "*...assign dates from low incidence years to the nearest year of high incidence...*". This approach has been followed here. The averaged fire scar dates for each tree, derived from synchronous or near-synchronous radius ring counts, were arranged by nearest neighbour and placed in spreadsheet columns (Table 2.8). In this example, the decade 1940-1949 is represented by the year 1948 as being of high incidence. Where a "year of high incidence" in a decade was not obvious, fire dates within 4 years were averaged to derive a single fire year. Where decadal dates were clustered into two groups, the same approach was applied to derive two or more fire years within that decade.

As the record advanced toward the pith, accuracy is potentially reduced due to the accumulation of missing or false rings (Banks 1993, but see chapter 4). It is also possible that missing and/or false rings, counted on separate radii, can cancel each other out as suggested by Woodgate *et al.* (1994) for *E. sieberi.*

Therefore, where no clustering was evident such as for the decades 1860-1890 (Table 2.8) all within decade years, except P and E, were averaged. Where fire dates from different trees were found to occur within 4 years they were averaged and allocated a single fire year because a) fuel accumulation would have been unlikely to have supported injurous fires within 4 years (Mount 1970, Dickinson & Kirkpatrick 1987, Bresnehan 2003) and b) there was a lack of two scars within the period on any individual.

Site AR	**Fire year**	AR1	AR2	AR3	AR4	AR5	AR6	AR7	AR8	AR9	AR10	AR11	AR12
1990-1999	1996						96						96
1980-1989	1980 1985	80			85			85					
1970-1979	1972 1976		72		70		76	72	77	77		76	
1960-1969	1965						65						65
1950-1959	1952							52					
1940-1949	1948			48			48	45			49		47
1930-1939	1932 1938			38		38		36 32					
1920-1929	1924 1927					23	27	24					24
1910-1919	1912			12	15				13		12		10
1900-1909	1903			01			2			4			
1890-1899	1893		93		P90	P92				94			
1880-1889	1885						87	83					
1870-1879	-												
1860-1869	1866		65					68					
1850-1859	1856							56	56				
1840-1849	-		P49										
1830-1839	1835	37		34				E37				35	
1820-1829	1821	P21										P21	
1810-1819	1814			14					13				
1800-1809	-												
1790-1799	1795R?			E93			E97		P96				
1780-1789	1786R?									E86	E86		
1750-1779	-												E56

Table 2.8 Site AR used as an example for the consolidation of fire years to form a composite site fire chronology. From the various within-tree fire years, 21 fires between 1810 and 1999 (col. 2) were derived. Two probable regeneration fires (R?) occurred in ~1795 and ~1886. P = pith date, E = centre rings missing, pith year estimated using method described above. A fire was known to have occurred across this site in 1976.

In order to proceed with the development of a fire history from fire scars in these eucalypts, it is first necessary to establish the annuality of growth rings. The proper application of dendrochronology confers a high degree of precision to fire scar years. The next chapter therefore explores use of this technique in both young and old fire scarred eucalypts from several of the sites described above.

Chapter 3

The use of dendrochronology to determine eucalypt ring annuality

3.1 Introduction

Verification of the fire scar dates obtained by counting rings is highly desirable. Dendrochronology is commonly used to confirm fire dates in conifers and, less commonly, in hardwoods from forests and woodlands across several continents including Europe (Drobyshev *et al.* 2004; Groven & Niklasson 2005), the Americas (Brown & Swetnam 1994; Grissino-Mayer 1995; Swetnam & Baisan 1996; Brown *et al.* 1999; Heyerdahl *et al.* 2001; Stephens & Collins 2004; Wolf 2004; Gonzalez *et al.* 2005) and New Zealand (Ogden *et al.* 1998). The standard dendrochronological method involves *cross-dating*[1] tree ring sequences. The high degree of accuracy of this method is thought by some to be important in landscapes subject to very frequent fire (Madanay *et al.* 1982; Means 1989).

Exploration of the potential of dry forest eucalypts for dendrochronological analysis is an important first step in the process of verifying fire dates because the cross-dating process confers a high degree of veracity to a fire history constructed from fire scars (Brookhouse 2006a). The capacity of relatively young (< 100 yrs) dry forest eucalypts to show even a moderate degree of synchrony in ring widths or marker years is unknown. Older stems can extend the fire scar record back to precolonial times which can provide a comparative record of fire frequency. For example, Banks (1982) successfully cross-matched partial ring widths (and marker years) in older *E. pauciflora* stems which formed the basis of

[1] See section 3.2.2

a cross-cultural fire history for the Brindabella Ranges in the Australian Capital Territory. The usefulness of crossdating for dry forest eucalypts will be evaluated based on the degree to which synchrony is helpful in identifying fire dates.

This chapter tests attempts made to verify the annuality of eucalypt growth rings using dendrochronological techniques on the endemics *E. tenuiramis* and *E. pulchella* in a study of young trees and *E. amygdalina* in a study of old trees. Old trees of the widespread *E. obliqua, E. globulus* and *E. delegatensis* which also occur in the southeastern states of mainland Australia, are also examined.

3.1.1 Verification of the annuality of eucalypt rings

Eucalypts provide a readily available and widespread proxy for the determination of historic fire passage. They generally possess diffuse-porous growth rings which appear to be of an annual nature, authenticated in species from northern (e.g. Mucha 1979; McBride & Lewis 1984) and south eastern Australia (e.g. Green 1968; Dadswell 1972; Banks 1982; Brookhouse 1997). Formation and growth of rings is a function of cambial activity (Kozlowski 1971) which is initiated and affected by physiological and environmental conditions (Fritts 1976). In any particular year, unfavourable conditions may only stimulate partial cambial activity resulting in reduced or partial growth of an annual ring (Kozlowski 1971). Intra-annual rings occur when favourable growth conditions activate the cambium after latewood has formed (Jacobs 1955) and are particularly prevalent in tropical species (Jacoby 1989). Insect activity, drought, frost, fire and stand dynamics and possibly insolation can influence the development of false and missing annual rings in eucalypts (Banks 1982; Rayner 1992; Brookhouse 2006). However, such anomalies do not necessarily occur about the entire circumference and may be present over one radius but 'locally present or absent' on another on the same sample causing differences in the sequencing of ring widths (Fritts 1976; Dunwiddie & LaMarche 1980; Brookhouse 1997; Waring & O'Hara 2006).

Microscopic differences in growth structure, such as vessel distribution and cell wall thickness, can assist with identification of annual growth rings where ring boundaries are questionable and where such differences are consistent (Fritts 1976; Fahn *et al.* 1981).

Stem analysis was undertaken by de Beuzeville (1918) for *E. delegatensis, E. viminalis, E. dives* and *E. pauciflora.* He assumed ring annuality in order to determine growth curves for mensuration. This work has not been refuted and others have built on this foundation. *Eucalyptus delegatensis, E. globulus, E. obliqua* and *E. diversicolor* are important forestry species known to have more or less annual increments (Lyndsay 1939, Brookhouse 1997). Rayner (1992) found that *E. diversicolor* rings in young trees from southwest Western Australia (< 70 yrs) were macroscopically distinct and dominant trees consistently reflected an accurate ring count. Accuracy was reduced when sub-dominant trees were used and suppressed trees were out by about 50%. No significant differences between ring counts from non-plantation *E. diversicolor* of unknown age and plantation grown trees of known age were found (P = <0.05) when tested for tree age error (Rayner 1991).

Estimates of tree age from mean radial ring width measurements from *E. obliqua* and *E. fastigata* trees in Victoria (n = 100) were compared with 'dendrochronological analysis' from stumps of the same two species (n = 19) and found to be 'congruent' in all trees except three (Gibbons *et al.* 2000). No further information, including the dendrochronological methods used, was provided.

Unlike most conifer species eucalypts are not truly dormant and the boundary between latewood and earlywood, signifying the completion of one growth cycle and the onset of another, can sometimes be unclear (e.g. Ogden 1978; Schweingruber 1992). Brookhouse (1997) coined the term 'reverse latewood' where he used the mid-cycle boundary i.e. between earlywood and latewood to determine the annuality of *E. obliqua* rings. Brookhouse (2006b) was able to show annual resolution for partial ring width sequences of *E. obliqua* and *E.*

delegatensis in Victoria. In addition, the ring width data were strongly correlated with temperature.

When matched with recent known fire events in the Blue Mountains of N.S.W., *E. oreades* was shown to produce annual rings (Glasby *et al.* 1988) because fire scars were readily located despite this species being considered fire sensitive. *Corymbia citriodora* (syn. *Eucalyptus citriodora*), from sub-tropical southeast Queensland, also produces annual rings. The study of Akeroyd *et al.* (2002) confirmed the annual nature of rings by comparing ring counts and C^{14} in cellulose from samples from a single tree with atmospheric C^{14}.

3.1.2 Dendrochronology

Several decades ago, eucalypts were not generally considered to develop reliable annual rings (Ogden 1978; Schweingruber 1992). Subsequently, eucalypts have not been widely used to develop regional or local fire histories, although attempts to age fire-regenerated wet forest stands have been made (Hickey *et al.* 1999; Alcorn *et al.* 2001). Brookhouse (2006b) has concluded that *E. obliqua* and *E. delegatensis* can be successfully cross-dated and has suggested revisiting the suitability of *Eucalyptus* for dendrochronological enquiry (Brookhouse 2006a). The climatic investigations undertaken using dendrochronology and eucalypts in southeastern Australia report relationships of varying strength with rainfall. Cross-dating was not reported in any study. However, partial cross-matching[2] or ring width patterns between series from individual trees was identified (Strasser 1992; Semple 1994). Two studies reported no relationship between climatic variables and ring width sequences of *E. pauciflora* (Keith 1982; Smith 1997).

[2] The term 'cross-match' is used when a partial or entire series is synchronous, yet the allocation of an exact date to each ring cannot be confidently applied.

3.2 Methods

3.2.1 Sample processing and measurement

Computer-aided measurement and analysis programs were used in the initial stages of processing. They have been designed specifically to manually, semi-automatically or automatically locate ring boundaries and measure the distance between each ring from the surface of a wood sample. A range of statistical tools within these programs are used to assist with the assessment of cross-dating quality and chronology development (Schweingruber 1988; Cook & Kairiukstis 1989).

3.2.1.1 Computer aided procedures

Core samples are commonly mounted on a measuring stage equipped with a microscope through which ring boundaries are identified, marked and measured (Cook & Kairiukstis 1989). Partial cross-sections, if small enough, are processed in the same way. The data are then stored and examined in a tree-ring analysis program of which there are a substantial number available (Table 3.1). Whilst not comprehensive, the programs listed in Table 3.1 are most frequently used for analysis of ring width data in European and American dendrochronological investigations (Holmes 1986; Jagels & Telewski 1990). Some programs, such as FHX2, have been developed specifically to analyse fire scar data. However, input data must be from cross-dated trees (Grissino-Mayer 1995).

Program	Down load	Comm. Avail.	Trial version	Source	Main use
COFECHA*	yes	no	-	Holmes 1983	TA, CQ
ARSTAN*	yes	no	-	Cook 1985	TA, S
CATRAS	yes	no	-	Aniol 1983	TA
FHX2	no	yes	yes	Grissino-Mayer 1995	FH
TSAPWin	no	yes	yes	Rinn 2001	M, TA, CQ, S
WinDENDRO	no	yes	yes	Regent Instruments 1995-2006	M, DR
CooRecorder & CDendro	no	yes	yes	Cybis Elektronik 2004	M, DR, TA
Silviscan	no	no	no	Downes & Evans 1995 CRC for Forestry	M, TA

Table 3.1 Resume of commonly used programs for measurement and analysis of ring width data. M = measurement, TA = time series analysis, S = extensive standardisation options, CQ = crossdating quality control, DR = detects ring boundaries, FH = fire scar data analysis, * = part of Dendrochronology Program Library.

The International Tree-Ring Data Base (NOAA) and the Ultimate! Tree Ring Pages (Grissino-Mayer 1994-2006) readily supply tree-ring data and analysis programs for direct download or provide links to more complex and comprehensive commercial options. The Dendrochronology Program Library (Grissino-Mayer 1994-2006) offers a suite of analysis programs of which COFECHA and ARSTAN are but two. One innovative example is WinDendro (Regent 1995-2001) which uses a flatbed scanning system to photograph light-weight core samples from which annual ring features are digitised and analysed on a desk-top computer. However, wood samples (whole cross-sections) can sometimes be very large and not suited to standard measuring equipment and systems. The use of photographed samples enables measurement and analysis of whole cross-sections and provides a convenient way to access the entire surface of each sample. CooRecorder and CDendro (Cybis Elektroniks 2003-2006) are examples of programs which fulfil separate, yet complementary functions. CooRecorder and CDendro are recent developments from Sweden. The earlier CooRecorder measures and analyses ring width data and CDendro determines ring characteristics from scanned photographs. CDendro has the advantage of being able to process information from high resolution photographs and incorporates an analysis suite using a compound of widely accepted analysis programs such as COFECHA and variations thereon. Photographs of tree cross-sections must be of very high resolution for best results.

3.2.2 Crossdating

Crossdating is the fundamental premise and practice on which dendrochronology is based (Douglass 1941a; Fritts 1976). The aim of crossdating is to evaluate, correct and allocate year-to-year agreement within and between variations in the patterns of ring characteristics (Fritts & Swetnam 1989). Ring widths are most commonly used because they are readily obtained from increment cores or stem cross-sections. Various types of measurement equipment and statistical analysis software are widely available (e.g. Baillie 1982; Holmes 1983; Rinn 2002) and thousands of ring width chronologies compiled from areas on most continents are internet accessible for comparison via the International Tree-Ring Data Base (ITRDB) (NOAA 2006).

The process of crossdating is not straightforward because tree rings can be missing in a particular sequence due to measurement error or failure to identify a growth ring boundary correctly (e.g. Grissino-Mayer 2001). Other factors such as complete annual growth failure due to drought (Fritts 1976; McFarlane & Adams 1998), fire (Kharuk *et al.* 2005) or insect defoliation (Morrow & LaMarche 1978) can occur in some samples and not in others from the same stand. Intra-annual latewood formation can result in a partial ring included on one radius but omitted on another from the same sample. False rings occur when conditions are conducive for additional growth within the same period ascribed for the laying down of late wood. False rings can partially or entirely cover the circumference of a tree. This is particularly pertinent for eucalypt growth after fire where partial false rings are prone to develop around the site of an actively healing occlusion (Banks 1982). In other genera (e.g. *Quercus*) the opposite has occurred in that fire has been shown to produce discontinuous growth rings (Jordan 1966). Caution is recommended in the use of disturbance events for crossdating purposes because the likelihood of ring anomalies, false or missing rings, is increased due to the stressful effects of the disturbance (Zackrisson 1977; Fritts & Swetnam 1989). Eucalypts are opportunists and are particularly prone to the development of intra-annual bands, false and missing rings (e.g. Argent 1995). However, the use of a sequence of particular ring width patterns, or an individual marker year characteristic, can help with the identification and placement of the proper sequence of ring widths in a series, *especially* when there is a high likelihood of ring anomalies (e.g. Banks 1982). The feature, if correctly identified, serves the purpose of locating the same intra-series ring/s thereby providing a benchmark for at least partially synchronous segments.

Despite the array and availability of computer programs for checking and evaluation of ring width synchrony[3], there is no substitute for human judgement and experience in achieving successful crossdating (Douglass 1943; Fritts & Swetnam 1989).

3.2.2.1 Statistical evaluation

The following parameters are used in statistical evaluation of cross-dating success. These are widely used to describe and interpret the degree of success in the process of cross-dating in three main ways:

- by describing the strength of between series ring width synchrony;
- by indicating areas or partial series lengths which do not match; and,
- by suggesting possible best match positions for two or more series

[3] The terms 'synchrony' or 'synchronous' are used throughout and refer to a section of a ring width series which shows sequential agreement of ring width patterns.

Series intercorrelation

A measure of correlation between series provides a guide to possible errors when crossdating. Program COFECHA (Holmes 1983) looks at segments of years (default = 50, lag = 25) using a one-tail test of the distribution of the correlation coefficient with 48 degrees of freedom and reports on the 99% confidence level of significance (0-1). A series is correlated with the mean of the other series in the run. Series correlations below 0.3281, representing the critical level of the 50 year segments, are flagged on this basis. The ring width data are transformed prior to analysis to remove low-frequency variance by a process of filtering, modelling and log-transformation (Holmes 1983). The higher the correlation, the better the match. Errors and likely best fit positions between series are thus determined.

Gleichläufigkeit

Level of agreement between consecutive ring width slopes. The degree of similarity between two series based on the positive (upward) or negative (downward), trends of each width is expressed as a percentage of the number of intervals. Individual Gleichläufigkeit (GLK) (Eckstein & Bauch 1969) values are added up over the entire series and are commonly conveyed as *, ** or *** symbols indicating 95%, 99% or 99.9% agreement between series. Gleichläufigkeit values represent the overall measure of similarity between series.

Crossdate Index

The crossdate index (CDI) calculates a date index of possible series matches and uses the Gleichläufigkeit value and t-values to determine the quality of the series match (max = 1.000) by the formula:

$$CDI = (G-50+50*\sqrt{\frac{overlap}{max\ overlap}})*T$$

where

G = GLK+_SGLK+S_GLK+SSGLK/n   (n = number of operators in the numerator)

T = TVBP+TVH/2

In TSAPWin (Rinn 2002), both TVBP and TVH detrend, or transform, the ring width data prior to calculation of the t statistic to normalise the distribution.

Signatures show the number of decreasing and increasing members derived from the source series. They are used to weight the GLK calculation resulting in the SGLK parameter (RinnTech 2003). The _SGLK, S_GLK and SSGLK represent the signature years located in a series and are variants on the calculation:

$$SGLK = \sum(yi_j = x_{ij}) \text{ in } \%$$

Specifically: SGLK = signature Gleichläufigkeit – sum of the equal slope intervals in %, calculated referring to chronology signature years only; _SGLK = standard signature Gleichläufigkeit – sample is the sample series and reference is the chronology; S_Glk = signature-standard Gleichläufigkeit – sample is the chronology and reference is the sample series; SSGLK = signature-signature Gleichläufigkeit – both sample and reference are the chronology (RinnTech 2003).

Mean Sensitivity

The production of tree rings is influenced by many endogenous factors such as the release of hormones which trigger cambium division (Larsen 1956). Exogenous factors such as substrate, moisture availability, competition, dominance class and the location of the tree in the landscape variously influence the rate of growth increments, the shape of the stem, and the degree of stresses the tree experiences. For example, a tree growing on the side of a steep incline on a rocky dolerite substrate with shallow soils, poor moisture retention, low nutrient supply and changing temperatures will demonstrate generally poor growth and a sensitive ring width pattern which reflects these conditions (Fritts 1976). With antithetical conditions, a complacent series of rings, showing little year-to-year variation, is the result. A single series can demonstrate periods of sensitive growth and complacent growth (Fig 3.1).

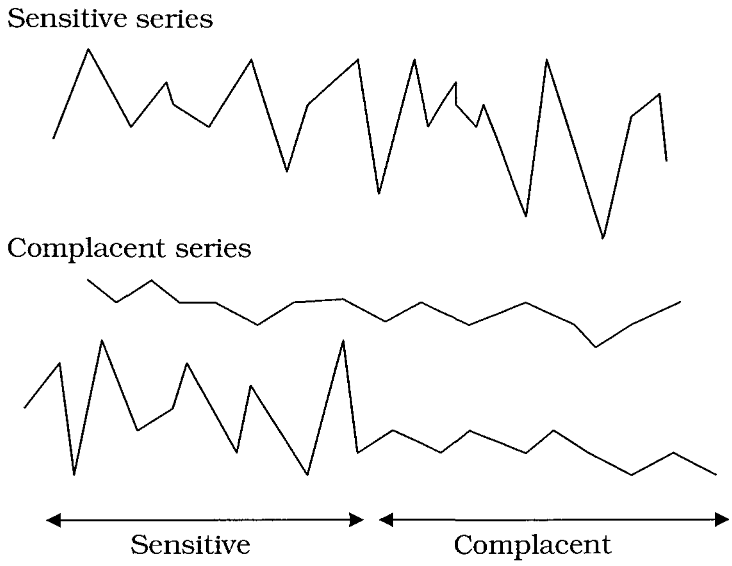


Fig 3.1. Sensitive, complacent and combined ring width series. A measure of change and variation between each years' growth, i.e. the mean sensitivity value, permits the assessment of environmental factors as an influence on growth. (After Schweingruber 1989).

Degree of sensitivity is the year-to-year (ring-to-ring) amplitude within a series and is the percentage expression of difference between two consecutive series values (0-1). The absolute values are averaged to derive the mean sensitivity and the higher the value the more sensitive the series (Schweingruber 1988). This measure is considered useful where site micro-conditions strongly impact upon tree growth (e.g. Heyerdahl *et al.* 2001). No information is available on the mean sensitivity of eucalypt series.

3.2.3 Tree ring signal or marker years

Signal years, as defined by Schweingruber *et al.* (1990) can be valuable signposts for the identification of region-wide events. A signal year can be characterised as a detectable pattern of one or several ring widths repeated within and between most samples over the site. Ring width, latewood/earlywood ratio, colour or other distinctive visual features were used by Banks (1982) to discern "marker" rings within a sequence in Snow Gum (*E. pauciflora*). Many different events can produce signals in a tree ring chronology. For example growth pulses after a fire event can be detected as a series of wide rings where nutrient availability and reduced competition has permitted an increase in the annual growth (Banks 1982). Where they occur concurrently signals can be difficult to interpret. For example a drought response can be characterised by one or several narrow bands of rings as can a seasonal partial or complete defoliation by phytophagous insects (Morrow & La Marche 1978). Where the annual growth increment is already reduced by the impact of low rainfall, the effects of defoliation can confound the tree ring signal by further reducing the annual increment in some or all of the studied trees (Mazanec 1968). Errors in interpretation of tree ring sequences as a result of endogenous events, such as defoliation, can consequently occur.

The process of standardisation, used primarily in dendroclimatology and in some fire histories where cross-dating was successful (e.g. Grissino-Mayer 1995), is designed to remove endogenous effects thereby facilitating the analysis of tree ring width patterns in a 'purer' environment. So, standardisation, or detrending, of ring width data can remove low frequency signal growth signals associated with disturbance (e.g. Cherubini *et al.* 1998). In dendroecology, it is these very disturbance events which may be of interest. Thus their significance as signal or marker years which can be cross-dated within and between samples is emphasised. Series standardisation may therefore impede discovery of such years.

Sampling methods were previously described in Chapter 2. The young trees were from site SH12D (refer Fig 2.6). The older trees were from sites SH12D, SH65A, MC21D and SW59C (refer Table .

3.2.4 Ring measurement

3.2.4.1 Development of an automated detect rings program

The whole cross-sections from the large trees were too big and heavy for stage-type ring width measurement and were not cut up into wedges because the entire surface was needed to assist with detection of ring boundaries and anomalies. The whole cross-sections were sampled when green. They deteriorated buckled, split, and broke apart within a matter of days and so were processed and photographed immediately. There was no computer-aided program (Jagels & Telewski 1990) available to manage the measurement of ring widths in whole eucalypt cross-sections.

In order to determine ring boundaries and measure ring widths from photographs, a program ("Detect Rings") was developed in an IDL environment. The program was in the School of Geography and Environmental Studies, University of Tasmania (Darren Turner). The particular requirements were to:

- differentiate eucalypt rings from each other from a digitised photograph;
- detect rings automatically while allowing for manual manipulation and over-ride;
- provide colour options to facilitate clarity
- progressively count the number of rings along a radius;
- allocate a calendar year to each measured ring based on the user defined outer ring date;
- measure the distance (1/100 mm) between each detected ring;
- convert the ring width data into an Excel compatible format;
- be user friendly and Windows™ compatible.

Time series analysis and statistical calculations were not required from the Detect Rings program since this process would be undertaken in TSAPWin. Three to four radii were carefully chosen from the photographs in Photoshop CS (Adobe Systems 2001) and 'cut' out. These radii were stored separately and individually loaded into the Detect Rings program. The image resolution (dpi from the input image) was calculated from a ruler positioned in the original photograph. A larger area incorporating each radius was also 'cut out' and displayed on the monitor at the same time. This served as additional reference material when checking ring boundaries in the Detect Rings program (Fig 3.2).

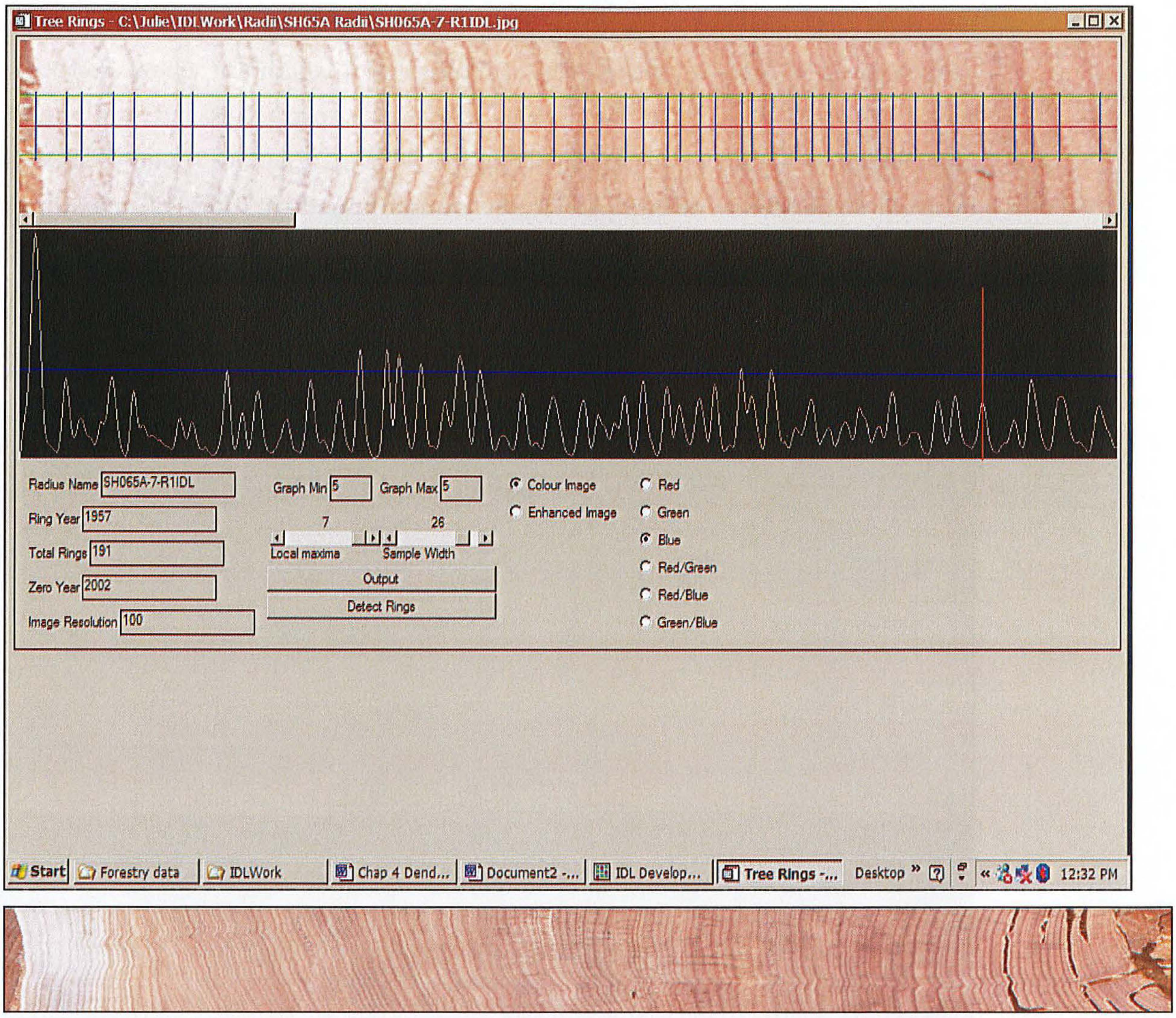


Fig 3.2 Screen shot of the Detect Rings program with an example of the additional information available from the 'cut out' of the same radius which is simultaneously displayed on the screen as a reference.

The Detect Rings algorithm determines the mean density of vertical pixels in the sample width. A running mean (10 values) is then created on a horizontal line which reduces noise and results in a smoothing effect. This meant that overall ring width patterns were able to be seen very clearly and were graphically depicted by the continuous oscillating line (Fig 3.2). The intensity change between latewood and earlywood is thus detected and a ring boundary, visible as a coloured vertical line, is inserted by the program at the point where it crosses the red horizontal line. This is a not dissimilar procedure to that used by MacDENDRO (Guay *et al.* 1992) from which WinDENDRO (Regent 1995-2006) evolved. Consistency of line placement is maintained by the local maxima width which allows for the detection of the highest amplitude at the ring boundary transition zone by checking for the mean of *x* points either side of a peak in the graph (Fig 3.3).

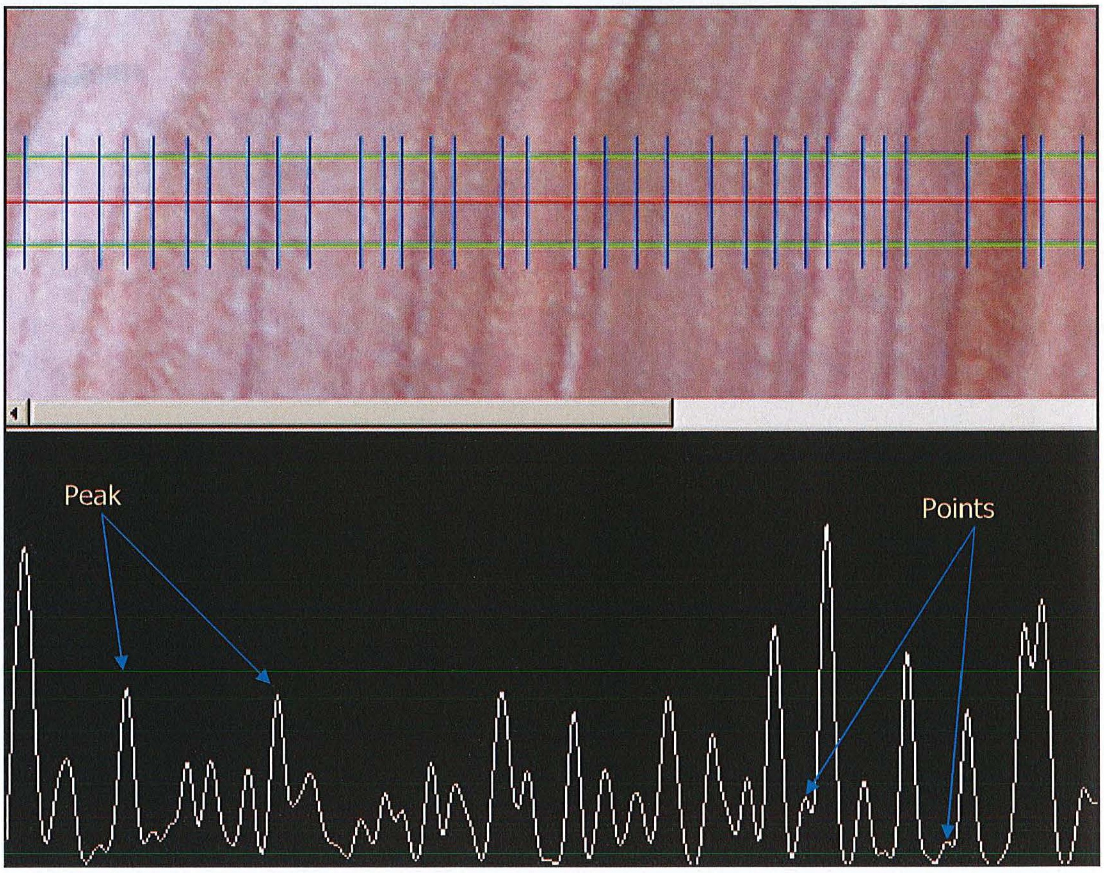


Fig 3.3 The graph responds to local maxima settings by moderating the amplitude which results in more or less points which are included in the peak position calculations. This shot shows a very smoothed graph (local maxima setting = 4) with few points either side of a 'peak'.

The local maxima setting defines the number of points each side of an intensity peak to which the program refers when searching for the correct placing of a tree ring boundary (Fig 3.3). This system is visually enhanced by the conversion of the image to greyscale (not shown). The standard image processing technique of convolution is used to detect the edges of ring boundaries which assists with ring boundary identification.

Ease of measurement was related to radius selection. Concave rings were difficult for the program to individually identify because of the range of vertical dark and light pixels in the same line. Six entire samples were discarded during the measurement procedure because it was not possible to discern ring boundaries in the program or because it was not possible to 'cut out' a clear radius. Periodically, small blurry sections were encountered along a radius. This could have been generated from a patch of incomplete sanding, a patch where the surface was excessively sanded in order to remove a scratch resulting in a dished out surface and/or improper camera lens focussing while photographing.

3.2.5 Analysis

Three or four measured radii per sample from both young and old trees were graphically examined in TSAPWin (Rinn 2001). In this environment series were moved manually to explore best fit positions. Several radii and/or samples were discarded during this process leaving a total of 44 radii from 13 young tree samples and 64 radii from 18 older tree samples. A number of statistical procedures were used to test the strength of series match positions.

Standardisation was not performed on the ring width data for the current study for two reasons. Firstly, the ring width series were not cross-dated. Secondly, the retention of marker or signal years in those fire years which did not scar each tree was considered an important potential identifying feature of the ring width data and its preservation therefore necessary. All series were checked for potential marker or signal rings based on size (differences in width between one ring and its immediate neighbours) and pattern – the matching of a particular series of wide and narrow rings in one series with a similar pattern in another, analogous to skeleton plotting (Stokes & Smiley 1968). This was attempted visually on the wood and graphically using between sample radii for both the young trees and the old trees.

3.2.5.1 Parameters used in TSAPWin and COFECHA

Statistical evaluations are designed to assist in identification of crossdating errors and are used to test the strength of series matches. The programs used in the analysis of the small samples were TSAPWin (Rinn 2001) and COFECHA (Holmes 1983). The graphical components of TSAPWin (graph and mathgraph) were used extensively. The large samples were analysed in TSAPWin only. The statistical parameters used to assess the strength of crossdating in TSAPWin were: Gleichläufigkeit (GLK), Crossdate Index (CDI), t-value Ballie-Pilcher (TVBP) (min 5, max 100) (Baillie & Pilcher 1973), t-value Hollstein (TVH) (min 3.5, max 100) (Hollstein 1973).

For the young trees COFECHA (Holmes 1983) was used to identify sections of within sample synchrony and areas of error. Where this did not result in increased synchrony of partial sequences a discordant radius (or sometimes two) was discarded resulting in a simplified mean series for that sample. Most within sample sequences for the young trees did not require the removal or addition of rings. Series inter-correlation values were calculated in COFECHA. Eucalypts were expected to return low inter-correlation values (K. Allen pers. comm. 2006).

Dendrochronologists insist upon successful cross-dating before subjecting a series to any form of indexation to ensure the correct ring has been placed in its exact year of formation (Fritts 1976; Fritts & Swetnam 1989). The undated ring width data were transformed by a smoothing spline in COFECHA before inter-correlation calculations were made (Holmes 1983). The default critical inter-correlation of 0.4226 for 30 year segments was used to identify areas of potential crossdating difficulty in the young trees and 0.3218 was used for 50 year segments in the old trees.

The CDI (arbitrary minimum of 0.2) was used to determine the best *between* sample individual radii matches from the entire sample set. These series were subjected to further scrutiny with the aim of obtaining the longest sequence of synchronous ring width patterns. In all analyses using TSAPWin, a single series, or mean series, from an individual tree was used as the reference for the development of the CDI since no master chronology was available. It is important to note that the entire range of statistical results must be scrutinised in order to decide whether a series qualifies as a significant match warranting further examination. The statistics cannot be examined in isolation from each other as this could lead to an erroneous decision. For this reason, the range of statistics, as output in the TSAP program, have been presented here, and in full detail in Appendices 1 and 2.

For the young trees, attempts to match within and between samples were made by dividing data into the following groups and processing as above:

- midslope samples (denoted by a 'c' prefix, e.g. C12ten)
- hilltop samples (no prefix, e.g. 000ten)
- same species (*E. tenuiramis*, *E. obliqua*, *E. pulchella*)
- groups of different species (*E. tenuiramis* with *E. obliqua*, *E. tenuiramis* with *E. pulchella* and *E. obliqua* with *E. pulchella*)

For the large trees, attempts to locate synchronous sections within and between series were made from individual trees and also by grouping data from the same species at the same site and by processing as above.

3.3 Results – young trees

3.3.1 Crossdating within samples

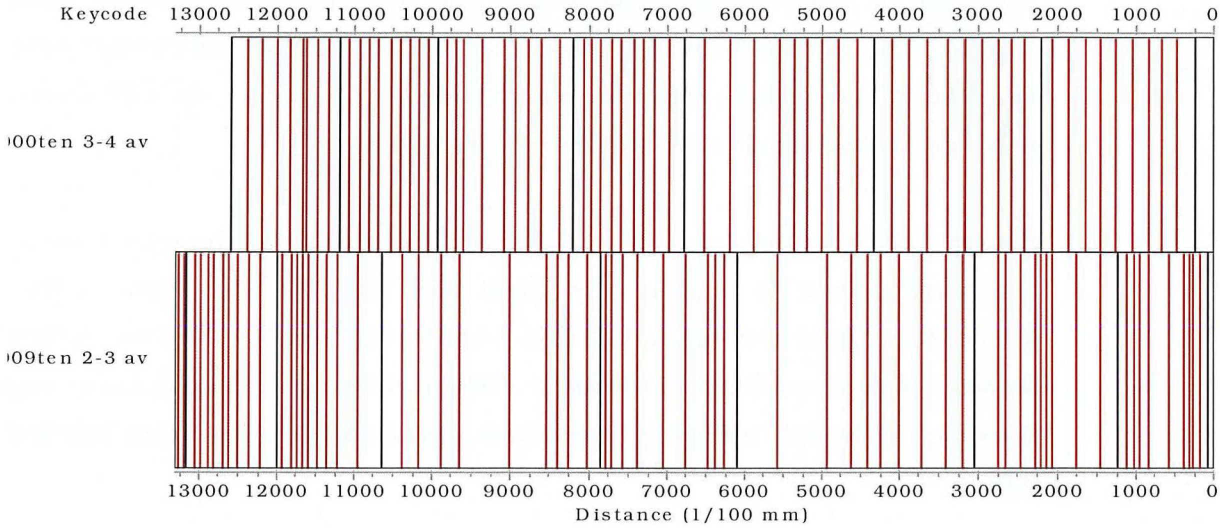
Successful cross-dating was not achieved within any of the samples of the young trees. Partial cross-matching was achieved within some samples as evidenced by high GLK and CDI (Table 3.2 and Fig 3.4).

Sample/radius	Reference	OVL	GLK%	GSL	CDI	TVBP	TVH	SIR	MS
000ten3	000ten2	63	65	**	0.27	4.5	3.8		
000ten4	000ten2	70	68	**	0.39	5.9	5.5	.607	.295
000ten3	000ten4	63	83	***	0.61	7.4	7.3		
003Aobl2	003Aobl1	110	75	***	0.53	8.6	5.7		
003Aobl3	003Aobl1	112	64	**	0.12	1.3	2.4	.455	.369
003Aobl2	003Aobl3	110	58	*	0.13	1.6	3		
003obl1	003obl2	130	57	*	0.15	2.6	2.5		
003obl1	003obl3	130	61	**	0.11	1	2.6	.440	.329
003obl3	003obl2	131	72	***	0.37	4.8	5.5		
004ten2	004ten3	73	72	***	0.35	4.5	5.2	.496	.317
007ten1	007ten2	88	74	***	0.48	6.7	6.3		
007ten2	007ten3	89	67	***	0.32	5	4.4	.455	.321
007ten1	007ten3	89	64	**	0.20	3.2	2.9		
008ten3	008ten1	77	57		0.10	1.8	1.7		
008ten4	008ten1	98	68	***	0.42	7.2	5	.490	.350
008ten3	008ten4	77	63	*	0.19	3.4	2.7		
009ten2	009ten1	74	72	***	0.39	5.8	4.9		
009ten3	009ten1	74	65	**	0.38	6.4	5.2	.607	.446
009ten3	009ten2	74	76	***	0.75	11.3	8.4		
c04obl1	c04obl4	155	80	***	0.28	14.8	17.2		
c04obl2	c04obl4	155	67	***	0.60	7.8	10.2	.631	.301
c04obl2	c04obl1	155	63	***	0.62	8.7	10.8		
c08ten2	c08ten1	88	74	***	0.47	6.7	6.2		
c08ten3	c08ten1	89	66	**	0.18	2.7	2.7	.421	.322
c08ten3	c08ten2	89	72	***	0.40	5.7	5.4		
c07obl4	c07obl1	114	65	***	0.23	3.7	3.5	.433	.390
c12ten2	c12ten1	136	60	**	0.24	4.7	3.2		
c12ten3	c12ten1	136	60	**	0.22	5	2.5	.387	.370
c12ten3	c12ten2	136	65	***	0.40	7.4	5		
006pul2	006pul1	132	58	*	0.11	2	1.7		
006pul3	006pul2	129	56		0.11	2	1.9	.113	.338
006pul1	006pul3	129	52		0.5	1.1	0.6		
c06pul2	c06pul1	110	65	***	0.28	3.3	5.4		
c06pul3	c06pul1	121	63	**	0.24	2.8	4.7	.068	.369
c06pul3	c06pul2	110	53		0.20	3	4.5		

Table 3.2 **Within** sample descriptive statistics from the 'best' results of the 13 samples. The highest SIR of 0.631 was recorded for sample c04obl while the best CDI of 0.76 was from 009ten3/009ten2. OVL = series length in yrs; GLK = Gleichläufigkeit (sum of equal slope intervals in %); GSL = Signature Glk (statistical significance of Glk: *=95.0%, **=99.0% ***=99.9%); CDI = cross-date index; TVBP = T-value Baillie-Pilcher; TVH = T-value Hollstein; SIR = series inter-correlation; MS = mean sensitivity.

The lack of cross-dating success and the seemingly contradictory statistics described in Table 3.2 can be explained with the example of c04obl1/c04obl4. The GLK is high at 80% with 99% significance (***). However, the CDI shows that this significance occurs over only 28 of the 155 rings.

Sample 000ten wore a very large fire scar which reduced the overall area from which radii could be measured to about 30% (Fig 3.5). This explains the high level of synchrony between radii 3 and 4 shown in Table 3.2. The two radii which showed high synchrony for sample 009ten were also located close together because the sample was very fragile and tended to fall apart when handled (Fig 3.6).



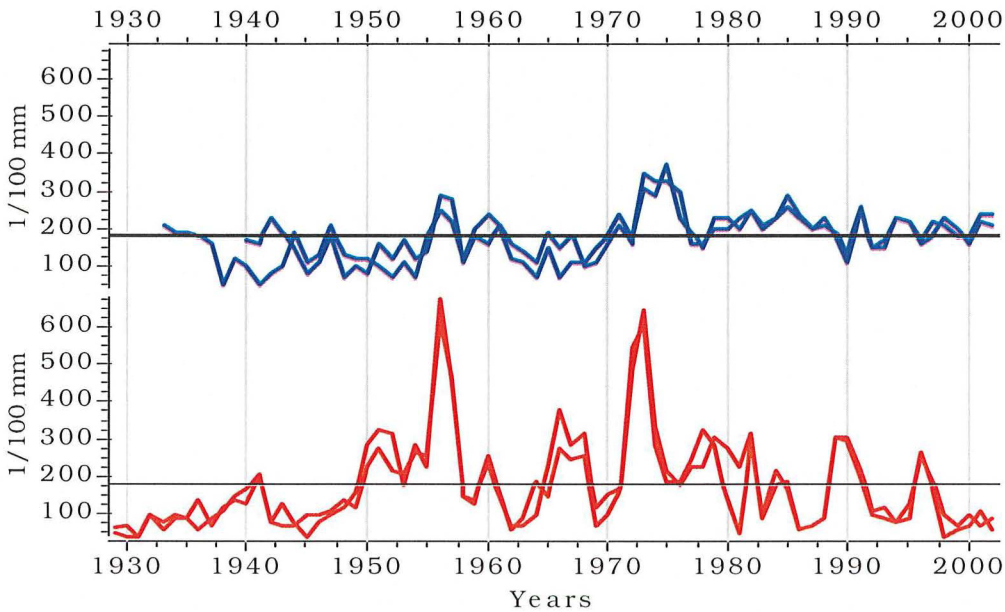


Fig 3.4. Synchrony of radii within some samples was very high (000ten radii 3 and 4, top, blue lines: CDI 61) and (009ten radii 2 and 3, bottom, red lines: CDI 75). 000ten was a relatively complacent sample (MS = .295) as evidenced by the relative width continuity of the top graph, but with very clear rings.

Fig 3.5 An example of the wood for sample 000ten showing radii very close together. The very large fire scar has limited the area available for measurement to ~30% of the surface.

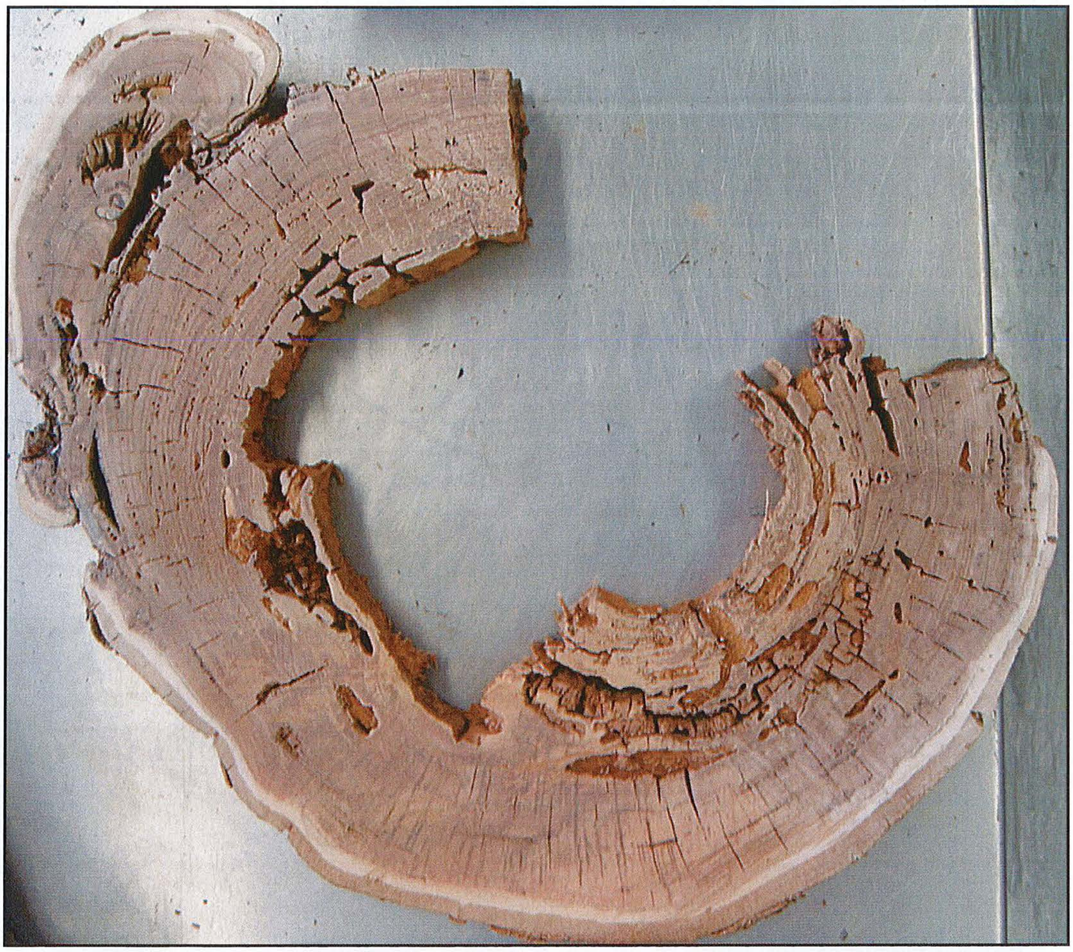


Fig 3.6 Remains of 009ten. Radii 2 and 3 were located in very close to each other in the top left hand section of the sample. The sample readily disintegrated upon handling.

3.3.2 Crossdating between samples

Cross-dating between samples resulted in very low scores in the evaluation parameters (Table 3.3). Partial synchrony between two samples of different species (004ten3 and 006pul2, shaded) scored a CDI of 0.35 and a high GLK but a low t statistic indicated very short segments of synchrony. All results from averaged series are presented in Appendix 1 (p. 277).

Sample	Reference	OVL	Glk	GSL	CDI	TV	TVBP	TVH
004ten3	c12ten3	73	65	**	0.30	4.4	5.5	3.8
008ten3	c12ten3	77	63	**	0.26	4.7	5.4	2.8
003Aobl1	000ten3	63	64	*	0.26	2.4	4.6	3.6
007ten1	000ten4	70	70	***	0.26	1.3	4.2	3.3
000ten2	003Aobl1	70	60		0.25	4	4.8	3.5
007ten2	003obl3	89	62	*	0.25	6.5	4.6	3.3
008ten3	004ten3	71	73	***	0.34	4	5.6	3.8
c06pul1	004ten3	58	73	***	0.25	1.9	3.9	3.5
c12ten2	004ten2	73	61	*	0.26	2	4.7	4.1
003obl3	006pul1	118	61	**	0.25	7.7	4.6	3.9
004ten3	006pul2	73	73	***	0.35	2.3	4.6	5.1
007ten3	006pul2	94	63	**	0.26	0.3	4.6	3.7

Table 3.3. **Between** sample descriptive statistics from the 15 samples (44 radii). Only 12 matches from a possible 122 series combinations scored higher than 0.20 CDI. OVL = series length in yrs; GLK = Gleichläufigkeit (sum of equal slope intervals in %); GSL =Signature Glk (statistical significance of Glk: *= 95.0%, **=99.0% ***= 99.9%); CDI = cross-date index; TV = value of T statistic; TVBP = T-value Baillie-Pilcher; TVH = T-value Hollstein; SIR = series inter-correlation; MS = mean sensitivity.

Partial synchrony, and the highest CDI value (0.35), between a radius from *E. tenuiramis* (004ten3) and *E. pulchella* (006pul2) highlighted in the above table cannot be related to neighbouring radii because two separate samples are involved. This result from the TSAP cross-date analysis showed that the best fit for the two radii was positioned such that the commencement year (2003) of radius 004ten3 was aligned with year 1981 on radius 006pul2 (Fig 3.7). Because the death date for all samples was known (2003) and measurements and determination of ring boundaries were conducted under a microscope, it is not possible that 21 rings were not included or were missing from this sample. Sapwood rings (10) were not estimated for sample 004ten indicating a spurious match.

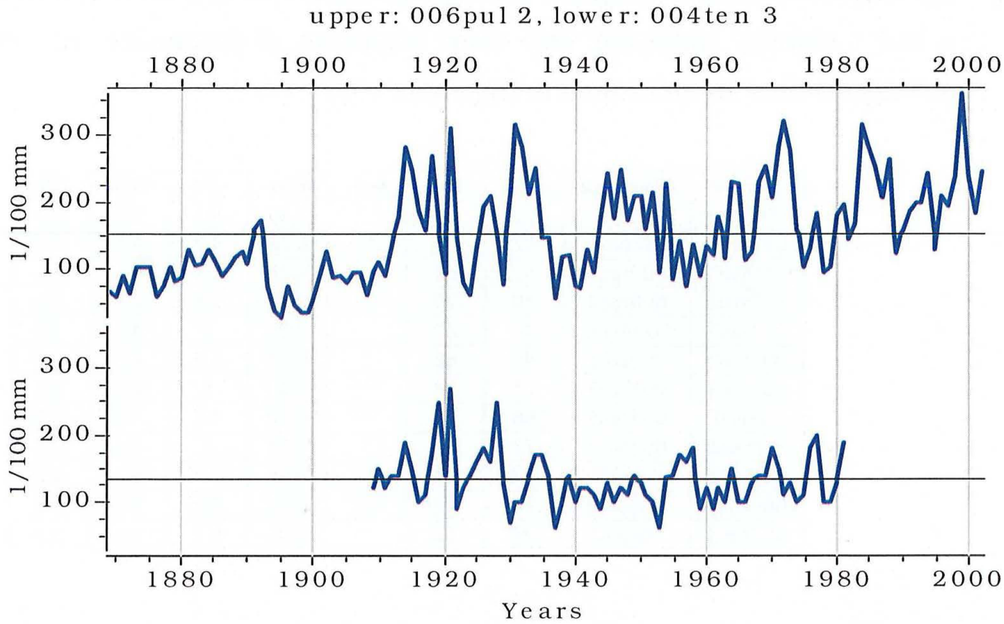


Fig 3.7 Graphical representation of the best fit relationship between radii from samples 006pul and 004ten showing suggested positioning of rings at the cambium end of the sequence.

An examination of all radii from the 13 samples in COFECHA showed low series inter-correlation between most samples.

Comparison of mean series between trees was attempted and abandoned due to continued low graphical ring width correlation. Analyses in both TSAPWin and COFECHA returned well below critical level values for inter-tree crossdating. Partial synchrony was not achieved in the intra-tree analyses.

3.3.2.1 Groups of samples

No synchrony was found between the eight samples representing the ridgetop group (000ten, 003Aobl, 003obl, 004ten, 007ten, 008ten, 009ten, 006pul) or the five samples from the midslope group (c04obl, c08ten, c07obl, c12ten, c06pul). A higher degree of synchrony was found between individual *E. tenuiramis* samples (000ten, 004ten, 007ten, 008ten, c08ten, 009ten, c12ten) than between individual *E. obliqua* (003Aobl, 003obl, c04obl, c07obl) or the two *E. pulchella* samples (006pul, c06pul). The two samples 003Aobl and 003obl were located adjacent each other but synchronous ring width patterns were not detected.

Between sample mean ring width comparisons proved unsuccessful. Mean ring widths from the two best matched radii were calculated for all samples and then for each of four samples (000ten, 007ten, c12ten, 003obl) as determined by the highest CDI statistic. Cross-dating proved impossible. However, close visual inspection showed a synchronous pattern of wide followed by narrow rings in short segments for the early 1960s (Fig. 3.8). This corresponds to a drought period and widespread fires in Tasmania (SES 1990). Synchrony also occurs in the early 1880s between two of the undated sequences. A period in the early 1990s showing a sequence (unmatched) of above average ring widths is evident (Fig. 3.8).

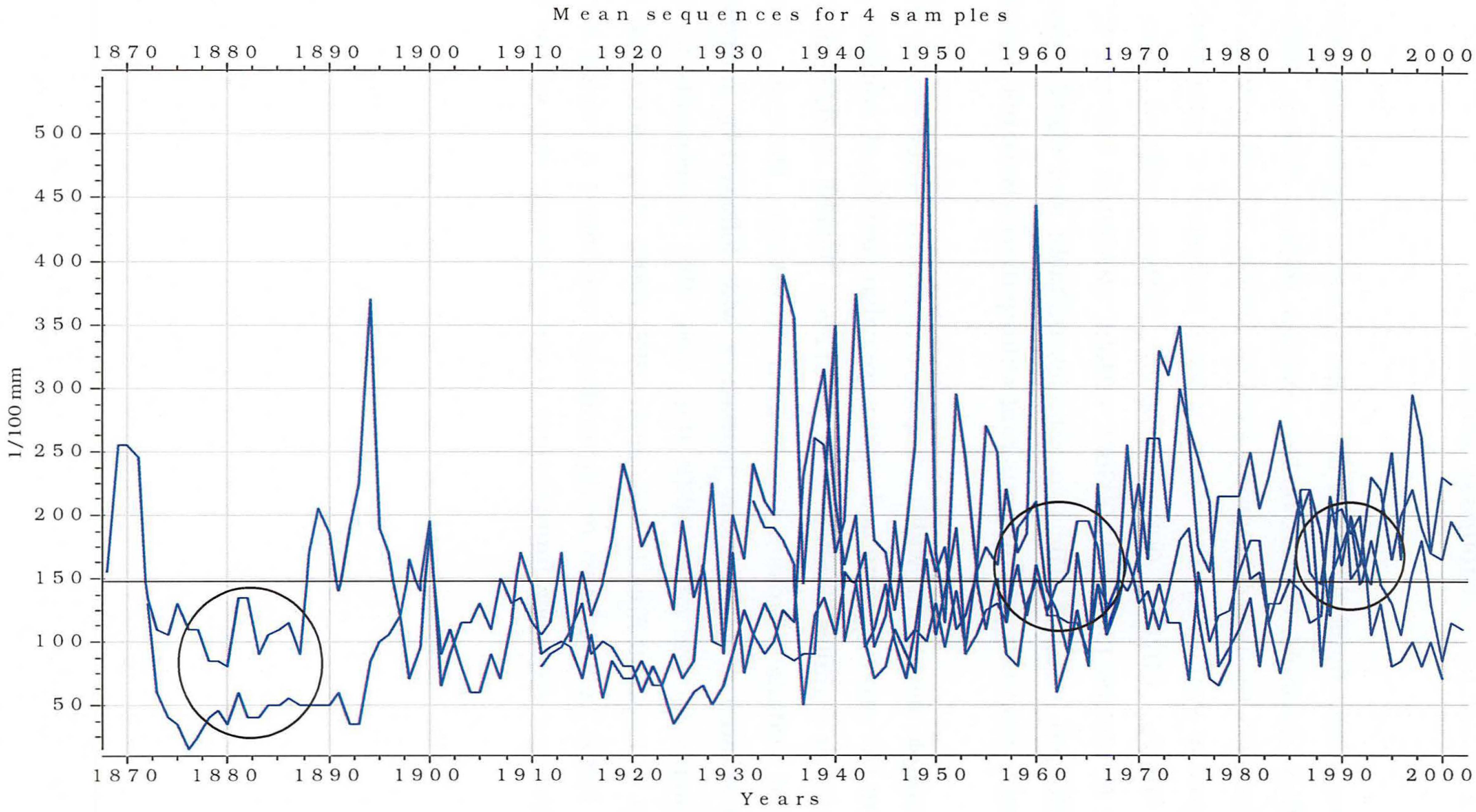


Fig 3.8 Mean series from four undated samples (000ten, 007ten, c12ten, 003obl). There is some synchrony in the early 1960s which corresponds with a Statewide drought and widespread fires. The early 1880s show partial synchrony for 8 years and the early 1990s, while not synchronous, demonstrate a period of various ring widths clustered above the mean. The periods referred to are circled.

3.4 Results - old trees

To minimise ring detection error, several different approaches within the Detect Rings program were used to measure each radius (n radii = 64):

- use of the programs' Detect feature without modification (automatic only);
- use of the programs' Detect feature but removing or adding a ring from time to time along each radius (modified); and
- detecting and marking each individual ring boundary along each radius (manual).

Various combinations of measurements were viewed in TSAPWin: automatic with automatic, automatic with modified and manual etc. and so on. Most confidence was placed in the modified mode of ring detection and these radii were subsequently used throughout the analysis. The programs' automatic mode mostly resulted in too many rings due to unclear sections of photographs (too dark or too indistinct). Manually detecting each individual ring on each radius is an enormously time-expensive exercise and is not recommended. In some instances, the Detect Rings program placed rings in positions missed by the manual effort.

The time series analysis of radii in TSAPWin was initially aimed at securing partial synchrony within samples.

3.4.1 Synchrony within samples

Crossdating was not achieved *within* any of the samples. The measured series returned very low scores from the statistical evaluation in TSAPWin. The 'bar-graph' facility in TSAPWin facilitates the detection of sequences of ring widths or marker years by graphically displaying individuals or groups of wide or narrow rings which aid crossdating (Fig. 3.9). The series are moved to align synchronous sections from which false and missing rings can be identified and accommodated in chronology development. No such synchrony was found in a single attempt to match any radius with any other radius. The example in Fig. 3.10, another way of depicting and working with the same data, clearly illustrates differences between sequential ring widths and synchronous patterns are absent.

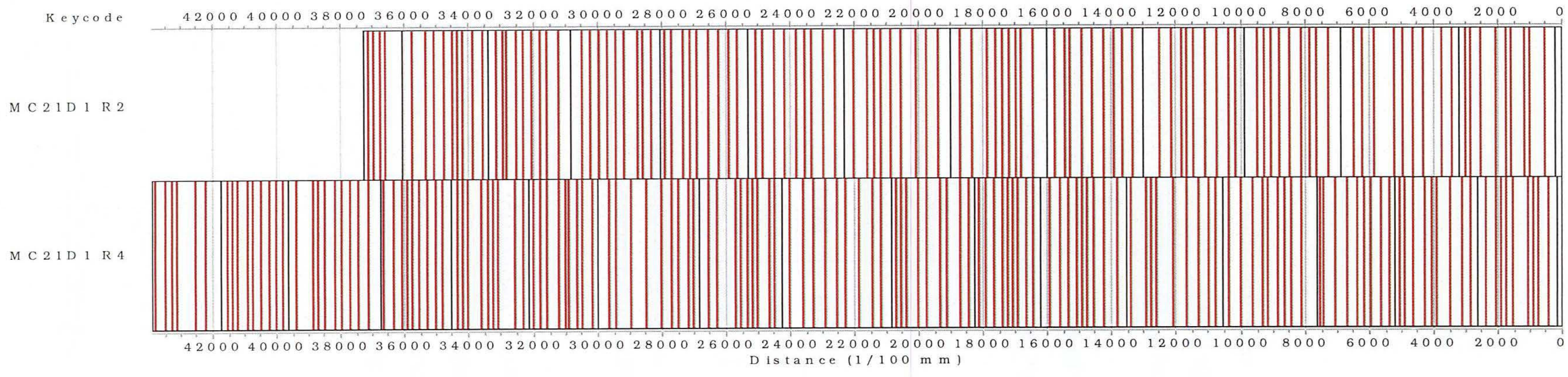


Fig. 3.9 Old tree MC21D1 radii 2 and 4 showing immense variation between radii. A synchronous, identifying sequence of wide and narrow rings could not be matched within this sample. (Distance is used as the measure on the x axis because the series are undated.)

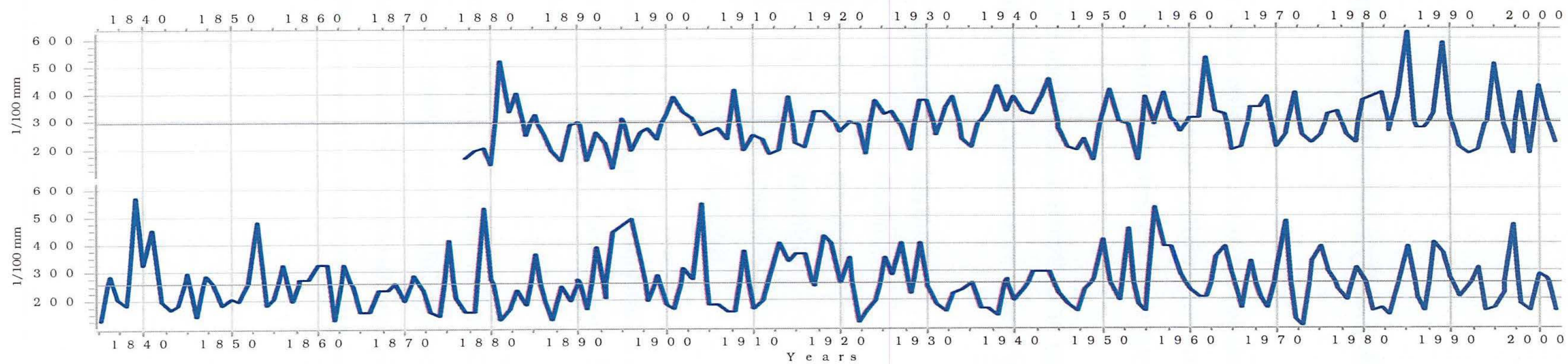


Fig 3.10 An alternative depiction of a lack of synchrony with sample MC21D1 radii 2 and 4 again showing immense variation. The mean ring width is shown as a line running through each series.

3.4.2 Synchrony between samples

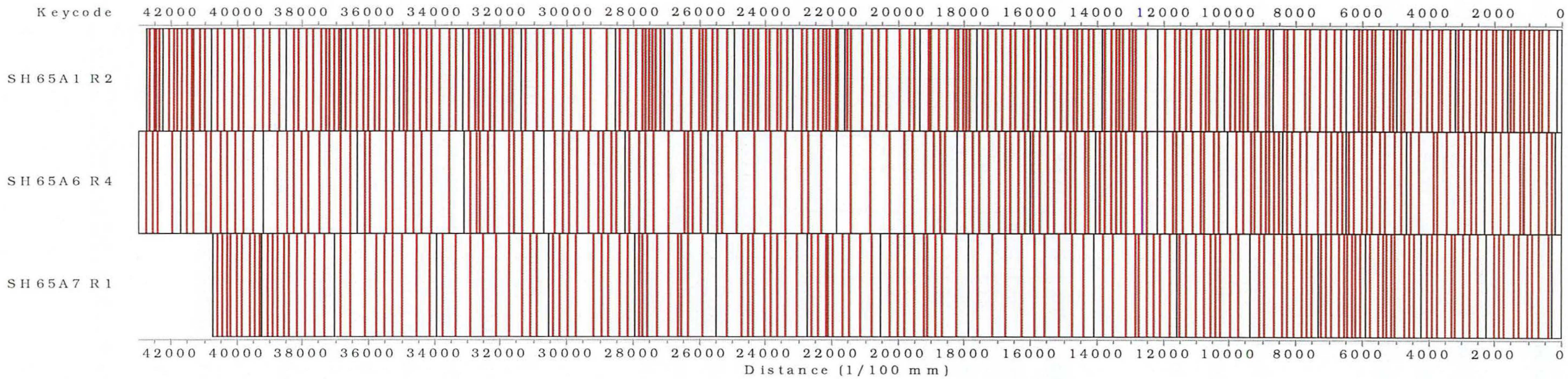
Crossdating between samples was not achieved in any instance. A chronology based on ring widths was not developed for the large trees. However, all results for averaged series from the cross-date run are presented in Appendix 2 (p.335).

The longest individual radii from each species were chosen to locate synchronous sections between samples, but within species, without success (Table 3.4).

Sample	**Radius**	**Species**	**ms**	**sd**
SH65A1	2	*E. amygdalina*	.36	69.1
SH65A6	4	*E. amygdalina*	.35	107.0
SH65A7	1	*E. amygdalina*	.39	98.4
SW59C1	3	*E. amygdalina*	.38	114.7
SW59C9	1	*E. amygdalina*	.38	98.1

Table 3.4 An attempt was made to match the longest series from each of five *E. amygdalina* samples with each other from the same site. Three samples from site SH65A and two from site SW59C. sd of mean series width.

The endemic *E. amygdalina* was initially thought to have especially distinct rings (comment by John Banks 2003 on photographed sample). The results of attempts to locate synchronous sections between different samples of the same species at the same site are shown for sites SH65A and SW59C (Fig 3.11).



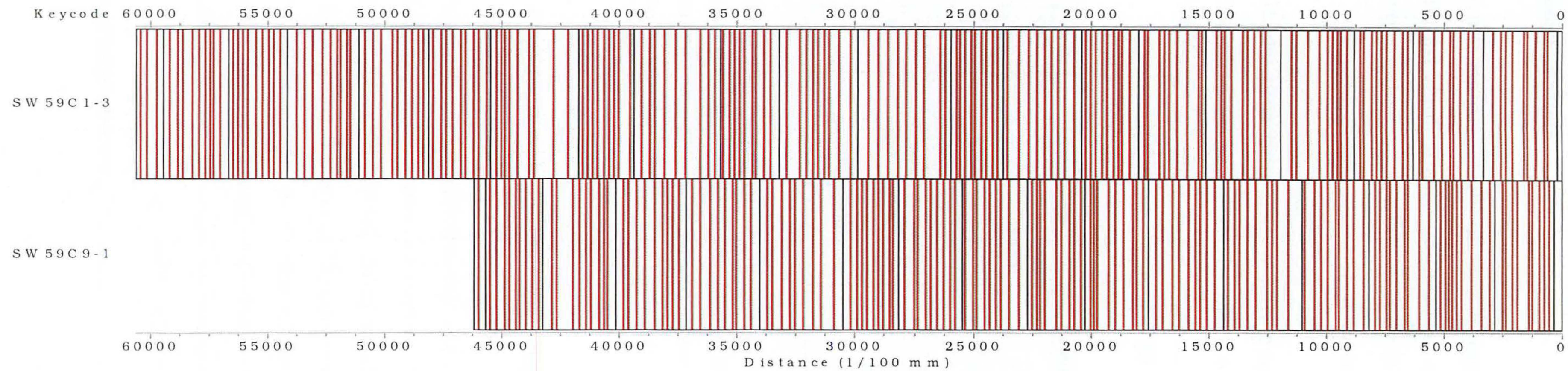


Fig. 3.11 Between sample, within site attempts to locate synchrony for *E. amygdalina* at SH65A top and SW59C bottom.
(Distance is used as the measure on the *x* axis because the series are undated.)

An attempt was made to match the mean series from the young tree samples 000ten and 009ten with a single radius from each of the large tree samples at site SH12D, all *E. tenuiramis*, despite a low likelihood of success due to the estimated differences in tree age (Table 3.5).

Matching ring widths and ring width patterns between old and young trees is fraught with inconsistencies arising from uncontrolled variables. Eucalypts of different ages show different growth curves at the various life stages (Rayner 1992; Woodgate *et al.* 1994).

Sample	Reference	OVL	GLK%	GSL	CDI	%CC	TVBP	TVH	SIR	MS
009ten	000ten	70	62	*	5	30	0.7	1		
SH12D1 4	000ten	53	73	***	20	19	2.9	3.2		
SH12D5 2	000ten	61	66	**	27	-8	4.5	4.1		
SH12D7 2	009ten	74	70	***	25	8	3.7	3.3	n/a	
SH12D1 4	mean 000ten009ten	74	56		12	-9	2.4	1.8		
SH12D5 2	mean 000ten009ten	74	58		11	-14	2.2	1.5		
SH12D7 2	mean 000ten009ten	74	59		18	15	3.6	2.7		
SH12D1 4 SH12D5 2 SH12D7 2	mean 000ten009ten								.075	.340

Table 3.5. Results of attempts to locate partial synchrony between individual and mean series of young *E. tenuiramis* and old *E. tenuiramis* from site SH12D, where the ring at cambium was formed in the same year for all trees. Series inter-correlation and mean sensitivity were not calculated. Column headings are explained on p.99 and in the caption of Table 3.2 on p.101.

In similar age classes, dominant trees tend to show strong growth at the expense of sub-dominant or suppressed trees which demonstrate their rank in a stand. Even with the advantage of a known death date (due to harvesting operations), growth curves for mature and senescing *E. sieberi* bore no relation to each other (Woodgate *et al.* 1994). Because the stumps in the present study were sampled from previously harvested trees, and were in the same stand, their stand rank was not known. It is highly unlikely that any ring width synchrony would be detected between vigorous young trees and suppressed older trees or any differing combination of age and rank. Therefore, no further attempts were made to synchronise series.

3.5 *Discussion and conclusions*

Marker rings or signal years were not found to be prevalent between trees. This is a common phenomenon (Schweingruber 1989). Because of the unknown quantity of false or missing rings in the ring width series, it was not possible to use fire scars as markers between samples. Characteristics of rings in which fire scars occurred, such as ring undulation or yellowed earlywood, were localised and not necessarily indicative of the same fire. Because exogenous events, such as fire, have a variable stand-wide effect, any changes in fire regimes could have potentially influenced individual tree growth. This would confound attempts at crossdating with ring width series because such events are recorded with great variability amongst individuals.

Heinrich & Banks (2005) used raw ring width data for an early exploration of the dendrochronological potential of *Toona ciliata* (Australian red cedar) in a similar way to the depiction of four series shown in Fig. 3.8. Showing groups of years with similar patterns can provide opportunity for discovery of partial synchrony not revealed by statistical analyses.

The high width variability within each ring (e.g. Rayner 1992; Argent 1995; Brookhouse 1997) and the unknown number of false and missing rings contributed to the overall lack of synchrony between series. Cross-dating is unsatisfactory for use with the sampled eucalypts from dry environments. The reasons for this are complex but several possible influences are worth expanding upon.

1) Environmental stress constitutes the response of a tree to an environmental factor over which an individual has no control. Examples are drought (Kirkpatrick & Marks 1985; Downes *et al.* 1999a) and frost (Davidson & Reid 1985). The impact of one form of environmental stress or another (Florence 1996) could reduce the capacity of an individual tree to lay down an increment of growth about the entire circumference resulting in a partial ring that is present in one measured radius but absent in another. Environmental stress of unknown origin has potentially effected a local influence in the sampled eucalypt individuals.

2) Insolation is another factor which could impact the growth responses of trees. For example, azimuth is most critical in winter months when solar elevations are at their lowest (Nunez 1983). Incident solar radiation is much less on south than north-facing slopes at this time than in summer. Within ring width variability was observed to be highly irregular. This indicates that growth around circumference is affected by an unknown element, or elements (Brookhouse 2006b). Trees could conceivably be responding to degrees of increasing or decreasing insolation on a particular azimuth. This could relate to photosynthate production occurring in a linear fashion between leaves and stem on the same azimuth. Within-ring width variability around the circumference could account for the failure of dendrochronological analysis to synchronise segments of some samples which had the same number of rings over each radius. Brookhouse (2006) found that low crossdating success in *E. obliqua*, was due to the use and inclusion of ring width series which were taken from the south azimuth. This occurred in three of his five sample sites and was not explained by slope or aspect. The *Sequoia sempervirens* coppice growth sampled in the study of Waring & O'Hara (2006) also showed partial rings and severe wedging in the area of each stem which received the least light due to shading. Levels of insolation were not measured in the present study nor were radii aligned with azimuth. Sampling radii from the same azimuth could potentially increase ring width synchrony.

The approximate annuality of eucalypt growth rings is well supported in some studies (Banks 1982; McBride & Lewis 1984; Rayner 1992; Rose 1993; Gibbons *et al.* 2000). Nevertheless, only one study reports successful cross-dating, and only for partial sequences (Brookhouse 2006b). Banks (1982) largely used signal years to match fire scars within and between trees for his fire history of the Brindabella Ranges near Canberra. The widths and relative widths do not vary synchronously to any great extent and are not suited to traditional methods of cross-dating.

The lack of success with dendrochronology techniques leads to the exploration of other methods for investigating the annuality of the sampled eucalypt tree rings with the aim of determining fire scar years.

Chapter 4

Evidence for the accuracy of fire scar dates using ring counts

4.1 Introduction

Determination of an error margin between the fire scar dates derived from ring counts and the likely fire dates from the ring width sequences (Madany *et al.* 1982) is an important aim of this study. Correlation of fire scar dates, derived from ring counting, with several external variables are other ways of estimating the accuracy of counting eucalypt rings. Such correlation can relate to:

- known fire events from the historical record,
- other trees of the same species of known age

An error estimate is desirable because the fire scar data can then be qualified. Except for the example immediately below, the following cases are cited to illustrate the usefulness of this approach in minimising uncertainty in ring counting.

Error estimates in the order of ±1-2 rings are sometimes stated for fire scar chronologies derived from conifers from western USA because species such as *Pinus ponderosa* are known to produce annual rings (Madany *et al.* 1982). For example, an estimated error of between ±1-2 years was proposed by Kilgore & Taylor (1979) for their fire history in the western USA where six conifer species were used. However, it is unclear how this estimate was derived.

Considerable error was found to occur in ring counts of second growth *Sequoia sempervirens* (n=22) from California (Waring & O'Hara 2006). When cores and cross-sections were compared, the probability of obtaining a maximum ring count increased from 30% using a single radius, to 43% using two. Cores typically returned lower ring counts than cross-sections. Analyses of cross-sections showed great variation in ring counts, which was attributed to missing and discontinuous rings and wedging. The authors concluded that stand age data derived from ring counts in this species are unreliable due to the high proportion of ring anomalies (Waring & O'Hara 2006). Reduced photosynthesis on the shaded side of the studied stems was proposed as an explanation for the observed wedging and ring discontinuity. This interpretation is similar to that of Brookhouse (2006b) who measured radii at each azimuth and proposed that variable photosynthate production in the crown on the southern side of stems led to ring anomalies in eucalypts.

Significant wedging in a New Zealand conifer (*Dacrycarpus dacrydioides*) resulted in the recommendation for use of the longest radius in determining tree age from ring counts (Duncan 1989). From 84 core samples a mean age error estimate due to missing rings was just 3% when the longest radius was used.

By locating a marker ring, caused by a freeze in the winter of 1955, in red alder (*Alnus rubra*), a diffuse-porous hardwood, DeBell *et al.* (1978) were able to determine ring count error. From 54 samples, they found that red alder rings were 85% reliable.

Koch (2007) in a detailed study of error estimates found that ring counting was the most reliable method to age *E. obliqua*. She developed and contrasted several models derived from growth curves in relation to tree diameter, ring counting and extrapolation and reported a total error of around 10% which increased linearly with increasing age. Results from Brookhouse (1997) were used to cross-reference the ring counting error.

In determining the accuracy of ring counts against cross-dated young trees (< 70 years), Brookhouse (1997) measured an error in comparative estimates of 8% for suppressed trees, a 7% error for dominant trees and a 3% error for co-dominants. This contrasts with the study of *E. diversicolor* in southwestern West Australia where Rayner (1992) reported ring counts to be 100% accurate for dominant trees, with decreasing levels of accuracy for co-dominant, sub-dominant and suppressed trees respectively where the ages of all non-dominant trees were underestimated.

An error estimation of ±6 rings per 100 was calculated for *E. regnans* by Banks (1993) which included estimations of missing centre rings. Cross-dating was unsuccessful. He used two samples but did not elucidate the details of his calculation.

Testing the accuracy of fire histories derived from ring counts is possible where fire records are known (McBride 1983). A comparison of '*more than a dozen*' recent tree fire scar dates derived from ring counts with USDA Forest Service Fire records resulted in accuracy to one year (Murray *et al.* 1998). Paired samples of fire scars were examined for a time period spanning several hundred years. Error in accuracy of matched dates was reported as varying only minimally between the 1700s (mean error 5.50 years) and 1800s (5.04), indicating that cumulative error was not evident.

Burrows *et al.* (1995) regressed estimated fire dates from old (> 250 yrs) *E. marginata* trees with known fire dates reliably documented by the Western Australian Department of Conservation and Land Management since the early 1940s. Whilst no regression equation was reported, a line of perfect agreement was fitted through the fire scar data derived from ring counts and the documented fires.

Ring counts from *Eucalyptus obliqua, Phyllocladus aspleniifolius* and *Agastachys odorata* near the Hogsback Plain in southern Tasmania, were used by Podger *et al.* (1988) to calibrate the occurrence of fire with historical records. Most (~90%)

fire scars dated to a recorded fire event. However, for a large number of fire scars in *E. obliqua* trees between 1920 and 1980 no related historical record could be found. The authors concluded that the historical record is '*seldom reliable enough to test for ecological hypotheses*'. Despite this conclusion, passage of historic fires in wet eucalypt forest in the Warra Long-term Ecological Research (LTER) area in the far south of Tasmania (Alcorn *et al.* 2001) was found to approximately match reported fires detailed in an earlier study at the same site (Hickey *et al.* 1999). Cohort ages were related to establishment in or after the year of fire. 'Notional' reliability of ring counts was reported as percentages of the sample size e.g. 59% had low reliability (15% error), 39% had medium reliability (10% error) and 2% had high reliability (5% error). It was unclear if error reliability was related to the number of ring counts which matched, or closely matched, the fire years and therefore cohort establishment.

Banks (1982) used documented fire records from various sources from 1858 – 1953 to substantiate fire scar dates derived from cross-matched fire scars, marker years and growth pulses in *E. pauciflora* from the Brindabella Range in the Australian Capital Territory. Most of the fire scar dates were confirmed from the very reliable documented fire record.

Knowledge of cohort ages in uneven-aged eucalypt forests is highly desirable for forest interpretation because processes affecting past stand establishment will, in all likelihood, continue to affect future stand development and thus yield (Bi 1994; Alcorn *et al.* 2000). Age estimates from ring counts of dominant trees can be related to fire events where these are known (Rayner 1992). Conversely, stand ages can be estimated from ring counts where fire passage is unknown, assuming that stand establishment is related to the passage of fire (e.g. Ellis 1985). Where regeneration has occurred as a result of the passage of known fires, estimation of ring counting error can be made by direct correlation of fire year and number of counted rings from samples of each cohort (e.g. Rayner 1992). Regeneration does not always occur immediately following a fire which renders this method of error measurement imprecise for taxa, unlike eucalypts, that have delayed establishment. Error can also be estimated from ring counts of samples from within stands of known age. Rayner (1992) reported that ring counts from dominant Karri trees (*E. diversicolor*) correlated exactly with stand age whereas ring counts from co-dominant and sub-dominant trees were out by up to 50%, severely under-representing their age. More commonly, knowledge of fire passage is unknown and fire dates are the desired result from the estimation of cohort ages.

Ellis (1985) estimated stand ages from several vegetation types based on ring counts from eucalypts in northeastern Tasmania. The successional process from grassland to rainforest enabled determination of the time since last fire for each stand resulting in the estimation of seven fire years, two of which were well documented from newspaper accounts (Ellis 1985).

Woodgate *et al.* (1994) used three different age cohorts to estimate fire passage through a forest of Silver-top ash (*E. sieberi*) in Victoria. Fires occurred based on fire scars dated from the ring counts. Growth pulses, determined from ring width data, were presumed to have resulted from passage of fire and together with dates from fire scars, comprised the basis for a site fire history. Tree rings were assumed to be annual because '*Reliable age estimates were obtained for the three regrowth trees as all had sound centres and relatively clear and easily recognisable tree rings*'. Extrapolation of annuality was then made to the older trees based on this examination of the younger, regrowth trees (Woodgate *et al.* 1994).

Schulze *et al.* (2006) measured radii from a large range of eucalypt species along a northeast/southwest rainfall gradient from Kalgoorlie into the Western Australian interior. They found that periods of growth, as determined by mapping of $\delta^{13}C$ on wood, were not strictly annual and were mainly related to rainfall. This is expected in the arid interior of Australia where moisture is the predominant limiting factor in eucalypt growth. No significant correlation was found between *Eucalyptus obliqua* and *E. delegatensis* growth ring increments and precipitation in Victoria (Brookhouse 2006b) which was an expected result given the high rainfall and deep soils of the environments on which the sampled trees were growing. Soil moisture, was not the limiting factor for the trees (Brookhouse 2006b).

McFarlane & Adams (1998) found that annual growth in young *E. globulus* was highly correlated with the previous seasons rainfall indicating a delay between drought conditions and reduced growth. δ13C of wood analysis showed that quantity and density of latewood was also reduced in water stressed trees (McFarlane & Adams 1998). Annual rings of young *E. globulus* in Portugal were identified by the use of vessel parameters (area, abundance and coverage) where reduced growth was also shown to be correlated with low rainfall from the previous season (Leal *et al.* 2004).

Interestingly, agreement between records of drought, wildfires and low rainfall index calculations was thought to be negligible by Jackson (1999), using The State Emergency Service (1990). He identified 1898, 1914, 1934, 1962, 1967, 1982 and 1988 as years of Statewide drought conditions.

This chapter aims to test the accuracy of fire scar dates derived from counting eucalypt rings by estimating error in four ways:

1. calculating the average deviation of radial ring counts for the entire length of the ring record for the older trees. This directly relates to cumulative error with age and will provide confidence, or otherwise, with ring counting;
2. estimating within sample differences in ring numbers through comparison of lengths of ring segments over several radii;
3. calculating the average deviation of ring counts for each composite fire date for a sample set of young trees (< 140 years) and an older sample set (> 150 years); and,
4. testing fire scar year correlation with known 'bad' fire years in young trees < 140 years.

4.2 *Methods*

The trees which were used for the analyses in the previous chapter were utilised here. Three separate analyses were performed to explore differences in ring numbers within and between samples. Data from the young and old trees were not pooled because ring width patterns for similar growth periods, ascertained in the previous chapter, were incompatible (Woodgate *et al.* 1994).

A composite fire scar chronology was determined for each of the 13 sites using the method described in chapter 2. A separate composite fire scar chronology was determined from the young trees for site SH12D. The average deviation for each individual tree fire year was calculated for the composite fire year for each site. A selection of photographs of the older trees were used to check for the prevalence of false and missing rings although specific rings were not identified as being false or missing. The average deviation for each radius from each fire scar year was calculated from individual tree fire scar chronologies. Each reference to a date or year is interchangeable and is an estimate unless otherwise stated.

4.2.1 Estimating the error of radial ring counts for tree age

4.2.1.1 Mean radial ring counts

A mean ring count was derived from between 2 – 4 radii for each of the older trees. To determine continuity, rings were traced around the stump circumference were possible. Estimates of ring numbers (using the method outlined in chapter 2) were included for those samples which lacked a centre. Thus each radial count commenced at the bark and terminated at the pith. The average deviation from the mean radial ring count was calculated for each radius, for each tree. This analysis addresses the aim of estimating the variability in calculating tree age for each sample and is especially relevant when viewed over time because two important temporal characteristics of the data are revealed:

1. whether ring counting error is cumulative via differences in deviation from the mean according to age; and
2. whether more synchronous radii counts are more likely with increased radius replication.

4.2.1.2 *Random ring count error*

From the older trees, rings were counted along several radii and compared by sections with the aim of ascertaining the prevalence of false and missing rings. Each ring was allocated from a photograph, every 10th ring was delineated and every 50th ring was allocated a cumulative date (Fig 4.1).

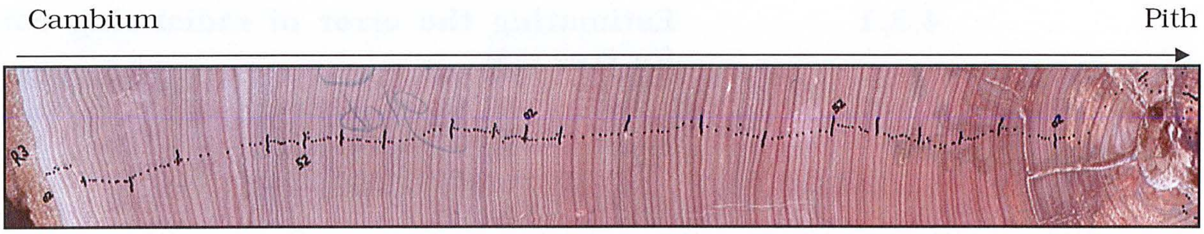


Fig 4.1. Radius from MC21D3 (*E. globulus*) showing delineation at every 10 rings and allocating the cumulative date every 50 years. Counting direction = cambium to pith.

The following analyses are different but each essentially compares the number of rings within a segment of two radii. No attempt was made to locate or identify false or missing rings or to allocate a date to any of the fire scars. The first analysis uses arbitrary segments of ~100 years, the second uses segments between sequential fire scar rings.

1) In order to estimate the degree to which false or missing rings were included in the fire scar date estimations, sections of each radius in the older trees were 'cut out' from the photographs. An example of two radii and two fire scars from which sections were cut is provided as an overview (Fig 4.2). From two radius segments, commencing and terminating on the same ring, it was possible to compare the difference between the number of rings starting over an arbitrary distance of 100 rings on one of the two radii.

2) The ring in which a fire scar occurred was traced to a radius and its ring number (date) compared with another fire scar from the same fire on the same sample. The number of rings between consecutive fire scars on a radius was compared with the same features on another radius on the same sample with the aim of identifying the difference in the number of rings between each sequence.

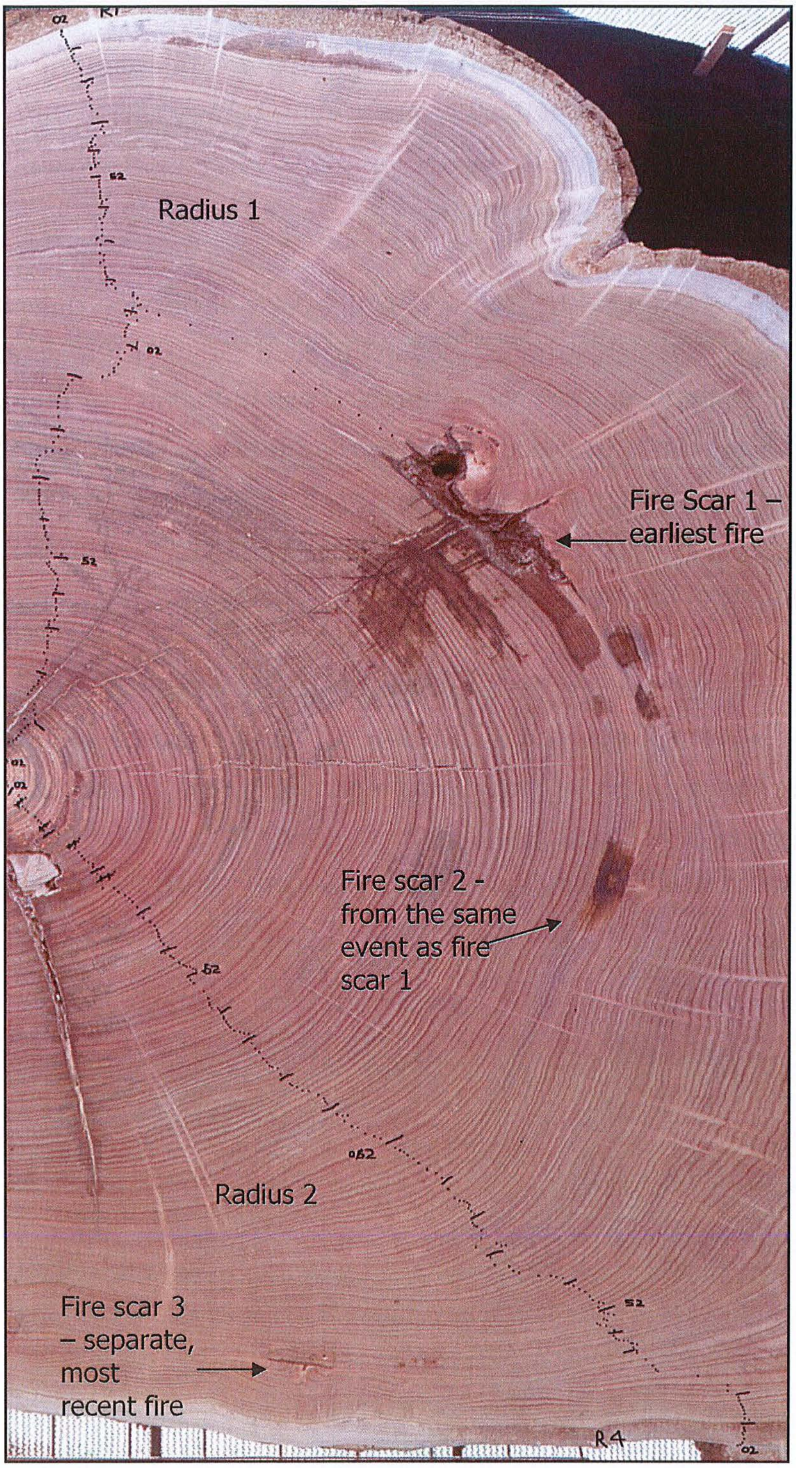


Fig 4.2 Overview of half of sample MC21D3 (*E. globulus*) showing location of two radii, allocation of dates and the presence of fire scars.

4.2.2 Estimating the error of fire scar years

4.2.2.1 Individual and composite tree fire scar year error

In order to assess how much movement was required to arrive at agreement between "years of high incidence" (Wagener 1961), fire scar year data from the young trees was tabulated. The number of ring adjustments necessary to arrive at each fire scar year was divided by the total number of fire scar years. This calculation was expressed as the mean error and is provided to illustrate an aspect of the process in section 4.3.2.2. It is more accurate to estimate the fire scar year error in terms of mean deviation from the mean number of rings used to determine the fire scar year because this method accounts for the number of radii used in the calculations which may affect the error margin.

Therefore, the mean deviation of ring counts from each fire scar year was calculated for each individual older tree at all sites and the younger trees at site SH12D. The incidence of divergent ring counts was calculated and their prevalence over time was assessed to check for any cumulative error.

This exercise is complicated by the fact that if more fires occur during a particular period of the chronology the error margin will be reduced due to lack of temporal opportunity for wider margins.

The average deviation for each composite fire year, for each site, was calculated from individual trees, including the young trees.

4.2.3 Correlations with 'bad' fire years

Spatially specific historic fire occurrence data for site SH12D were not available because fires were either not recorded by the managing agency, or records were inadvertently disposed of. Surviving Forestry Tasmania records show escaped fuel reduction burns occurred within 30 kms of SH12D in 1972/73, 1976/77 and 1981. In addition, several sources (Foley 1947; Wettenhall 1975; Luke & McArthur 1976; SES 1990; Pyne 1991) provided broad reference to 'bad' fire years in Tasmania. Ellis (1985) deduced fire years largely based on eucalypt ring counts for a site in northeastern Tasmania. The relationship (Chi^2) between fire dates from the young trees and 'bad' fire years enables a probability of co-incidence to be established. This was calculated using the both the young tree fire scar chronology and the chronology from the older samples from site SH12D.

4.3 Results

4.3.1 Radial ring error estimates for tree age

Mean radial ring counts approximated tree age. The average deviation of rings did not increase with increasing tree age (Fig 4.3).

This indicates that ring count errors do not accumulate over time. Mean average deviation of number of radial rings (n = 94) was 6.8 rings (range 0.5 – 20.5). There were 10 trees which were aged from a single radius which were consequently not included in the analysis.

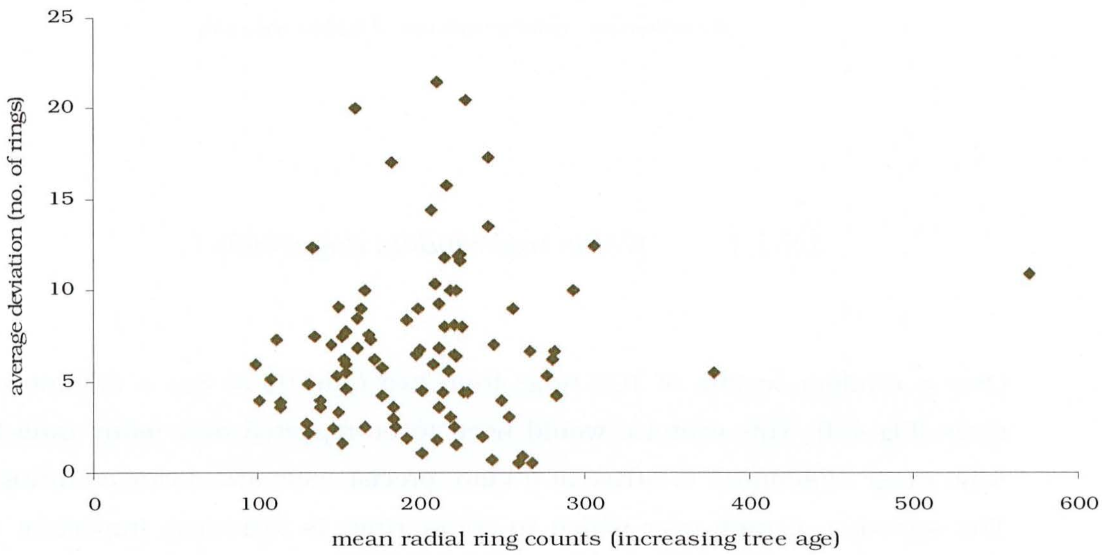


Fig 4.3 The average deviation of the number of rings did not increase with increasing tree age. All older trees (n=94) with combined radii counts of between 2 – 4 are represented. Mean average radial deviation = 6.8 rings.

Using more than two radii reduced the mean average deviation (Table 4.1). There was no indicative pattern evident in site or species which influenced the decreased mean average deviation of rings. Increased replication appears to be the factor determining the lower mean error.

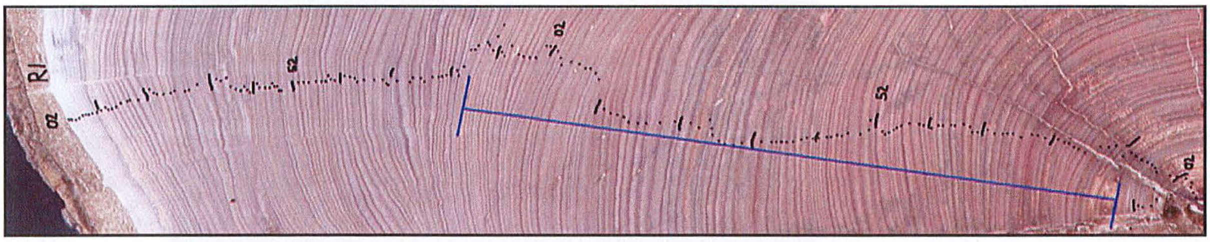
no. of radii	2 (n=21)	3 (n=49)	4 (n=24)
mean average deviation (no. of rings)	7.8	6.8	5.8
median	6.5	6.2	5.8
range (no. of rings)	0.5 – 20.5	0.7 - 17.1	1.9 – 13.5

Table 4.1 More replication decreased the overall mean average deviation of rings. The median also decreased marginally with use of additional radii.

4.3.1.1 *Within tree random ring counts*

Over a random section of 100 rings from two radii there was a difference of ±6 rings (Fig 4.4). This exercise would need to be repeated over many radii from a wide range of samples to arrive at a more precise estimate of ring counting error. The selection of radii over which to count rings is extremely important and is guided by ring clarity and distant proximity from fire scars. Wedging occurs in areas between buttressing and is impossible to navigate (Fig 4.5). This means that in order to trace rings between radii, they will usually be located relatively close to each other (depending on degree of buttressing and location of fire scars). This brings into question the fruitfulness of further attempts at such an exercise because it is preferable to locate radii away from each other. However, the selection of sample MC21D3 on which this exercise was performed, displayed wedging and buttressing and the tracing of the same ring between the two selected radii was relatively unhampered through the middle section of the tree.

Radius 1



Radius 2

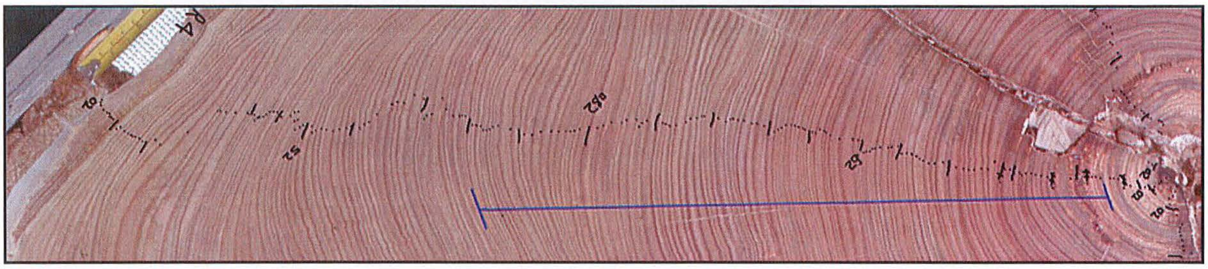


Fig 4.4 Two radii showing 100 rings along the blue line. There are six extra rings on the lower radius or six less rings on the upper one. Counting started from the same pith ring. A fire scar was navigated in the outer rings – refer Fig 4.2.

Fig 4.5 Wedging between buttressing renders the tracing of individual rings impossible in this section of a sample. Sampling height = 1 m.

Addressing point 2 from section 4.2.1.2, the difference between the number of rings from cambium to fire scar ring on two radii of sample MC21D3 was four rings over a distance of ~84 rings.

Counting was continued from the first fire scar to the third. There were 61 rings between the first and third fire scars on radius 1 (earliest and latest fire scars) and 58 rings on radius 2, a difference of 3 rings over a distance of ~61 rings. Location of the fire scars and radius selection is shown in Fig 4.2.

4.3.1.1.1 *An example of local ring counts*

Verification of the annual nature of the rings in three eucalypt species was obtained near Hobart at a site which was burned in the bushfires of February 1967. Recent fire history for the site is known. Single stems of *E. pulchella* and *E. tenuiramis* (two from each species) were selected from discrete stands of 1967 regeneration and cut down in the winter of 2003. Rings were counted on the stumps from the cambium to pith. Counts of between 33-35 rings were obtained for all four stumps indicating that either regeneration was occurring up to two years after the 1967 fire or two rings were missing in one sample. In addition, two large stumps of *E. obliqua*, bearing scars from the February 1967 fire were available in the winter of 2003. Exactly 36 rings between cambium and the fire scar ring were counted in each stump on a surface section away from the scar.

4.3.2 Fire scar error estimates

4.3.2.1 *Individual tree fire scar year error*

There was an initial indication that divergent ring counts for fire scar years increased with increasing distance from the present (Fig 4.6). However, this is not a sign of cumulative error with increasing age. With increasing fire occurrence in the 20th century, there is less opportunity for widely divergent ring counts because the maximum number of rings available is set by the next fire scar year. Details of all fire scars from each stump at each site are provided via chronologies in chapter 6.

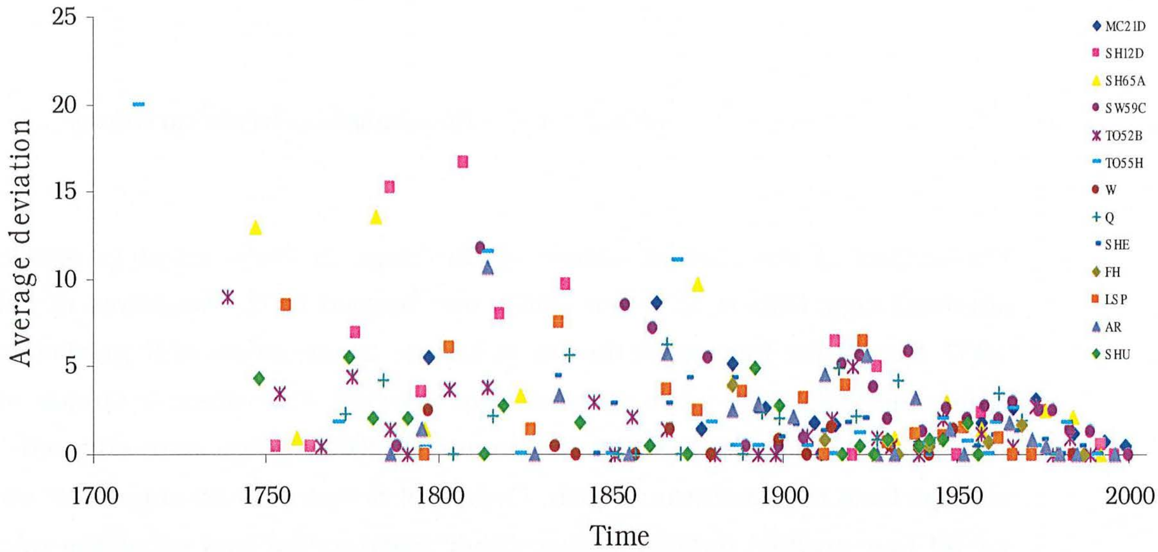


Fig 4.6 Average deviation of radius ring counts for each individual fire scar showed spurious increased deviation with increasing age. More fires have reduced the opportunity for wider divergence of ring counts in the 20th C and error is not cumulative for this reason.

4.3.2.2 *Composite site fire scar year error*

Young trees. No fire date from an individual sample has been adjusted by more than three years (sample 003obl), with eight adjustments occurring over two years (000ten, 003Aobl x 2, 004ten x 2, c04obl and c05ten x 2) and six adjustments occurring at one year (002obl, c04obl, c06pul, c07obl x 2 and c12ten). There were four samples (006pul, 007ten, 008ten, 009ten) which required no date adjustment. Therefore, for relatively young trees < 100 years, the mean error (15 adjustments/35 scar dates) = 2.3 years. The average deviation of years for the young tree composite fire scar chronology is 0.6 rings (Table 4.2).

Cumulative error was accounted for by looking at the incidence of dates which were moved earlier or later to match the most likely fire year over the length of the record. Of the 15 adjustments, 11 were moved to an earlier year indicating a mild propensity toward overestimation. The remaining three adjustments were moved to a later year. Some samples required a single adjustment in each direction (004ten, C04obl and C05ten). The example of C07obl shows that two early adjustments were required; at 1975 (1 year) and at 1948 (1 year). It is not possible to move the entire series back a single year because between 1975 and 1948 is another fire scar date for 1970 which is also found in sample 008ten. In addition, the fire scar date for 1899 is also found in another sample. There appears to be no cumulative effect (i.e. anomalous rings or sequences of consecutive rings can occur over any part of any radius) from missing or false rings in the process of deriving composite fire scar dates.

The example shown in Table 4.2 is for the young trees and is depicted tree by individual tree.

[1]Cal. Year	000 ten	002 obl	003 Aobl	003 obl	004 ten	006 pul	007 ten	008 ten	009 ten	C02 ten	C04 obl	C05 ten	C06 pul	C07 obl	C12 ten	[2]Est. fire year	[3]Av. Dev.
1978																	
1977			x														
1976														x			
1975			x	x					x			x		x		1975	1
1974																	
1973												x					
1972																	
1971																	
1970								x						x		1970	0
1969																	
1968					x												
1967																	
1966			x		x					x					x	1966	0.8
1965																	
1964																	
1963	x																
1962																	
1961	x												x		x	1961	1.1
1960													x				
1959																	
1950			x														
1949														x			
1948			x									x		x	x	1948	0.8
1947																	
1943																	
1942				x													
1941											x						
1940															x		
1939				x	x						x	x			x	1939	1.4
1938																	
1937					x												
1936																	
1935																	
1934											x				x	1934	0
1933																	
1930																	
1925																	
1924												x					
1923																	
1922											x	x				1922	1
1921																	
1920																	
1918																	
1917		x															
1916		x				x	x	x			x					1916	1.4
1915											x						
1910																	
1909																	
1900																	
1899						x								x		1899	0
1890																	
1884														x		1884	0
						Mean average deviation (rings):											0.6

Table 4.2. Composite fire chronology with initial dates shaded in grey. These were moved to a position within 1-3 years above or below in accordance with neighbouring "years of high incidence". Dashed lines demark each decade. The mean average deviation for this composite chronology is 0.6 rings. [1]Cal. = calendar, [2]Est. = estimated, [3]Av. Dev. = average deviation.

Older trees. The average deviation (years) between composite fire scar dates and fire scar dates derived from radii on individual trees ranged from 0 – 4.5. The vast majority of fire scar dates balanced out as shown by the clustering at zero along the *x* axis (Fig 4.7). The development of a composite site chronology required the adjustment of many dates, a summary of deviations which appear in Table 4.3.

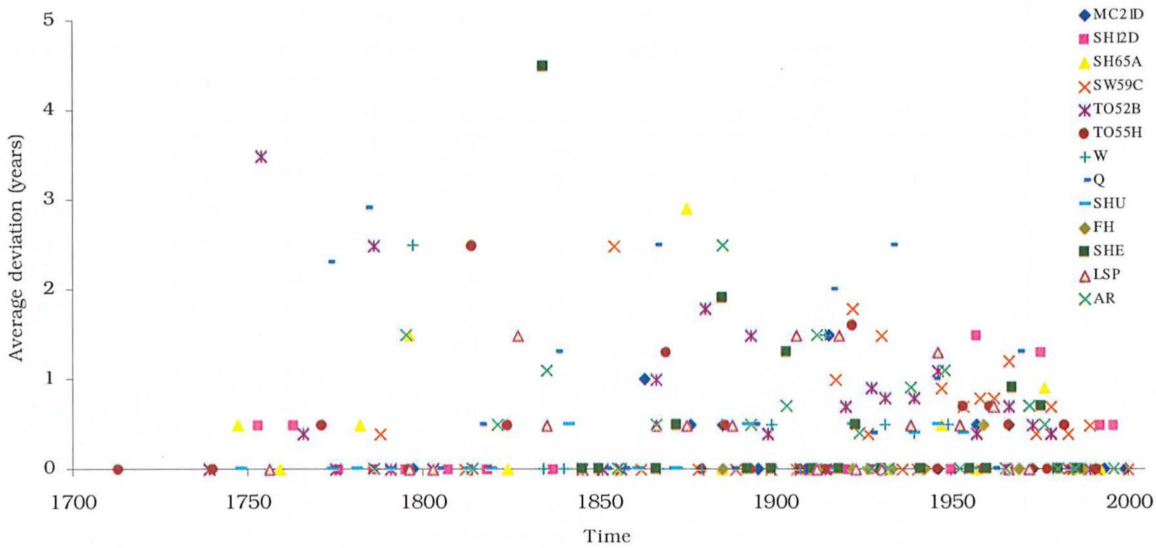


Fig 4.7 Average deviation (years) from individual tree fire scar dates to composite chronology fire scar years.

The widest divergence was not reflected in the earlier (1700s) fire scar dates from the oldest trees. The average mean deviation of 0.4 (range: 0.06 rings at site FH to 0.79 rings at site Q) indicates close agreement between trees. However, a proportion of composite fire scar years were derived from a single scar on a single tree. This proportion is expressed as a percentage of all fire scar years by site in Table 4.3. When these single record years are removed, the mean average deviation of rings in determining fire scar years is 0.7 rings (range: 0.08 rings at site FH to 1.04 rings at site TO52B).

Composite site fire scars	MC21D	SH12D	SH65A	SW59C	TO52B	TO55H	W	Q	SHU	FH	SHE	LSP	AR
↑	0	0.5	0	0	1	0	0	0	0	0	0	0	0
	0	0.5	0	0	0	0	0	1.3	0.4	0	0	0	0
	0	0	0.9	0.5	0.5	0.5	0.5	0	0.5	0.5	0.7	0.7	0
	0	1.3	0	0.4	0.5	0	0	0.5	0	0	0.9	0.5	0.5
	0.5	0	0.5	0.7	0.5	0	0.4	1	0.4	0	0	1.3	0.7
	0.5	1.5	0	0.4	0.7	0.5	0.5	0	0	0	0	0.5	0
	0	0	0	1.2	1.1	0.7	1.5	2.5	0	0	0	0	0
	1.5	0	2.9	0.8	0	0	0	0.4	0.5	0	0	0	1.1
	0	0	0	0.8	0	0.7	0.5	0.5	0	0	0.5	1.5	0.9
	0	0	0	0.7	0	0	0	2	0		0	0	0
	0.5	0	1.5	0.9	0	0	0	0	0.5		0	1.5	0
	0.5	0	0.5	0	0	1.6	0	0	0		1.3	0.5	0.4
	1	0	0	0	1.5	0	0	0.5	0		0	0.5	1.5
	0	0	0.5	1.5	0	0	0	0	0.5		0	0.5	0.7
		0		0.4	0	0	2.5	0	0		1.9	0.5	0.5
		0		1.8	0	0.5		2.5	0		0.5	1.5	2.5
		0.5		1	0	0.5		0	0		0	0	0.5
		0.5		0	0	1.3		0	0		0	0	0
				0	1	0		1.3	0		0	0	1.1
				0	3	0.5		0.5	0		4.5		0.5
				0	1	2.5		0					0
				0	0	0		2.9					1.5
				0	0	0.5		2.3					0
				2.5	1.3	0							
				0	0	0							
				0.4	0								
					3.5								
↓					0								
% of single records	7	61	50	31	46	40	53	17	20	33	35	11	17
mean average deviation	0.32	0.27	0.49	0.54	0.62	0.37	0.39	0.79	0.14	0.06	0.52	0.5	0.54
Adjusted mean av. deviation	0.35	0.69	0.97	0.85	1.04	0.65	0.84	0.96	0.18	0.08	0.79	0.56	0.65

Table 4.3 Each figure represents the average deviation of years, for each fire (most recent: 2000s to earliest: 1700s), between each individual tree fire scar date and the composite site fire scar chronology. The mean average deviation for each site increases when those fire scar dates which are recorded from a single radius are removed (adjusted mean average deviation).

4.3.3 Correlations with 'bad' fire years

There was good agreement between 'bad' fire years derived from Luke & McArthur (1978), Wettenhall (1975) and Pyne (1991) and the composite fire scar years. Six out of 11 fire scar dates occurred in bad fire years, a result much higher than expected ($Chi^2 = 22.4$, d.f. = 1, P = < 0.001).

Other reports of fires in the east of the State and the Midlands were identified according to their location in rainfall divisions (Foley 1947: 34). When fires occurring in the relevant rainfall division (92 or 93) were extracted, new fire years emerged (Table 4.1). The years reported by Foley (1947) were derived from attendance by the fire suppression agency of the era and were used to compare meteorological conditions with fire occurrence. 'Bad' fire years were shown to correspond with 'bad' fire weather. None of the sources contain locale information, although Ellis (1985) is site specific at Mt. Maurice in the northeast, there is insufficient detail for any fire to be pinpointed at SH12D nor any of the other combined study sites when fire scar years were combined (Table 4.4).

Foley (1947)	Wettenhall (1975)	Luke & McArthur (1977)	Ellis (1985)	SES (1990)	Pyne (1991)	Fire scar years – young trees	Fire scar years – older trees
						1894	
	1897						
		1898		1898	1898		
	1899					1899	
			1908				
1912							
1914		1914			1914		
	1915			1915	1915		1915
						1916	
			1920				1920
1922						1922	
				1926			
				1927	1927		1927
					1932		
	1934	1934		1934		1934	
1936							
1939	1939		1939		1939	1939	
1940	1940			1940			
1941							
		1945		1945			
						1948	
							1950
			1956				
							1957
		1961				1961	
				1962			
			1963	1963			
				1964			
			1966	1966		1966	1966
	1967	1967		1967			
				1968			
						1970	
				1972			
						1975	1975

Table 4.4 'Bad' fire years derived from six different sources. Years in blue represent matches with published years from the young tree chronology and years in orange represent matches with the older tree chronology. None of the sources mention locations in the study area although some are area specific e.g. Swansea, St. Marys.

4.4 Discussion and conclusions

The results showed that estimated tree ages have a mean error of ~7 rings in older trees while an average mean deviation of <1 ring is likely when the counts from several radii are averaged to derive a fire scar year regardless of tree age.

The difference of ±6 rings per 100 calculated using the two radii from the *E. globulus* sample is the same as that of Banks (1993) for *E. regnans*.

Both the young and older trees showed ring counting error was not cumulative. The estimated radial ring error of 7 rings included counts taken from two, three and four radii. This error estimation reduced to 5.8 rings when four radii were used in the tree age calculations. Waring & O'Hara (2006) also increased the reliability of ring counts in *Sequoia sempervirens* when their calculations included additional radii.

Divergence in the calculation of fire scar dates was minimal when the average deviation of years was calculated for fire scar years in the older trees. The maximum divergence was 4.5 years because fire scars were encountered more frequently in the late 20thC part of the chronology. The average mean deviation is < 1 year reflecting a high degree of reliability and confidence in the allocation of fire scar years.

The error analysis resolved that the averaging of different fire scar dates derived from several (2-4) radii is likely to account for both false and missing rings as postulated by Woodgate *et al.* 1994. Since missing and false rings were not identified in the present study this statement remains unverified. However, the large percentage of fire scar dates which were consolidated into a single year from dates that fell within one or two years does confer merit to this premise. This is especially so for those fire dates which were synchronised in stumps over long time periods (>15 decades) such as samples TO55H7 and TO55H8 (fire scar in ~1713), samples Q11 and Q12 (fire scar in ~1773) and samples SW59C1 and

SW59C4 (fire scar in ~1788). The comprehensive fire scar chronologies are presented in chapter 6.

Having established that eucalypt rings provide a relatively consistent platform on which to base the fire history, a further strengthening of the data is desirable. This can be achieved by searching for sources of error through various forms of data interrogation. The next chapter reports a range of analyses which identify and eliminate potential sources of error.

Chapter 5

Identification and elimination of potential sources of bias

5.1 Introduction

It has been established that there is error associated with the counting of eucalypt tree rings because they cannot be shown to be annual (chapter 3). However, chapter 4 shows that this level of error is likely to be variable, but relatively low.

Sample size can affect the completeness of the fire scar chronology. The variability of fire behaviour and fuel dynamics can combine to produce scars in some trees but not in others in the same stand, as outlined in Chapter 2. It is therefore desirable to test for adequacy of fire capture.

Completeness of fire capture has been identified as a vulnerability in fire history reconstruction (Johnson & Gutsell 1994). A fire may fail to leave a scar in every burned location, a severe fire may erase previous records and sampling may not detect all past fires (Wagener 1961, Arno and Sneck 1977). While stratified random (Johnson and Gutsell 1994; Fulé *et al.* 2003) and targeted (Swetnam and Basian 1996, 2003) sampling methods differ in approach, they both aim to maximise fire capture.

How many trees provide an adequate sample-set? Adequacy of sample size is usually assessed using fire scar data (e.g. Fulé *et al.* 2003). Using a procedure analogous to a species-area curve, Fulé *et al.* (2003) found that 100% of fires were captured by an average of 80% of their samples indicating a robust sample size. Trees with a high number of fire scars recorded 68% of all recorded fires in contrast with only 17% of fires being recorded by those trees with few scars.

An adequate sample size varies with research objectives, species availability and site variability (Agee 1996). Burrows *et al.* (1995) conclude that uncertainty in spatial fire occurrence could be mitigated by a large sample size (~30 from each site), while simultaneously noting the impracticality of such an undertaking in old-growth eucalypt forests.

The availability of suitable trees will largely determine quantity. However, at least one repeatedly scarred tree from each site is highly desirable and can compensate for a smaller sample size (McBride 1983; Agee 1996; Fulé *et al.* 2003).

The propensity for particular species of eucalypt to more readily record fire scars was shown to be related to bark type (Gill & Ashton 1968). This laboratory study examined three species and determined the time required for each of a rough, stringy and smooth barked eucalypt to form a scar after a measured application of flame. The stringy-barked species, *E. obliqua*, most readily formed a scar in the shortest amount of time, followed by the rough barked species, *E. radiata*. The gum-barked *E. cypellocarpa* recorded the lowest rate of heat penetration to the cambium apparently due to the lower flammability of the bark. The present study used the natural distribution of fire scars from seven eucalypt species (trees > ~200 yrs) to test for species bias which could influence interpretation of the fire scar chronology. For example, if *E. obliqua*, a stringy-barked species, is more prone to fire scarring when young than gum-barked species, fires in young *E. tenuiramis, E. dalrympleana, E. globulus* and *E. pulchella* may not be recorded thus biasing the site chronology.

Older trees may be more susceptible to scarring by fire due to a halo effect resulting from an accumulation of fuel in the immediate vicinity (Banks 1982). If so, the exclusive use of old trees could bias the fire frequency towards detection of those fires occurring later in the life of the trees. Trees, when young, could be reliable recorders of low intensity fires due to their thinner bark (Gill 1974), since high intensity fires would be likely to kill them. Maximum bark thickness is generally not attained in young eucalypts (Gill 1974). Low intensity fires, depending on fuel condition, arrangement and continuity, could more readily scar young trees than old trees due to lower protection from heat because of their thin bark thus leaving a record of fire passage whilst leaving the tree alive. The halo effect and the bark thickness effect may cancel each other out. In utilising wild trees for analyses of these influences, temporal variations in fire incidence need to be examined.

Fuel characteristics play a major role in determining the formation of a fire scar. The reconstruction of a fire history is, by nature, a retrospective exercise. Therefore, precise fuel properties at the time of each fire cannot be included as a potential influence on the formation of fire scars in eucalypts. However, the position of the tree in the landscape, slope, aspect, and bark thickness are known and may pre-dispose an individual to the formation of a fire scar. The influence of these variables can be ascertained in relation to fire scar numbers and assist in the elimination of additional sources of bias.

This chapter addresses the potential influence of four main potential sources of error or bias:

- the possibility that sample size influences the number of recorded fires at sites;
- the possibility that different species of eucalypt affects the number of recorded fires at sites;
- the possibility that the age of the tree influences its susceptibility to fire scarring; and
- the possibility that other factors such as slope, altitude, position in landscape, bark thickness and diameter over bark predispose an individual to scarring.

5.2. *Methods*

5.2.1 Data collection

This study uses data obtained from photographed samples and field based sampling, the collection and preparation of which have been described in previous chapters. The distinction between the two types of samples is not relevant to the detection of fire scars. However, those sites from which photographed samples originated and those from which data were collected in situ are indicated below (Table 5.1). The sampling criteria were identical.

The sampling methods were detailed in Chapter 2 (section 2.4.2) and sampled species are shown in Table 5.1. The varying sample numbers used in the analyses reported in this chapter are stated in the relevant section.

Site/Species	SH 64A	Q	SH 12D	W	TO 55H	TO 52B	MC 21D	FH	AR	LSP	SHE	SW 59C	SHU	Total samples
E. amygdalina	5				3	1	4		4	8	1	2	6	34
E. globulus	1						1	5	6	1	7	2	1	24
E. delegatensis						8								8
E. tenuiramis			7											7
E. dalrympleana		11		5		1								17
E. pulchella									2	1			1	4
E. obliqua	1				4							5		10
Photographs	x		x				x					x		104
In situ		x	x	x	x	x		x	x	x	x		x	

Table 5.1 Number and species collected from each site. Origins of collected data from photographed samples and stumps in situ.

5.2.2 Data analysis

5.2.2.1 The effect of sample size

The number of trees sampled from each site differed according to availability and suitability. To account for potentially missed fire scars at those sites with low sample numbers, the number of fires needed to be adjusted by the relationship between sample number and fire year capture. Similar in concept to a species-area curve, when all fire years are captured as additional samples are introduced, the curve would be expected to reach a plateau. Conversely, should the curve continue to rise proportionally with the addition of samples without flattening off then a low rate of fire year capture would be concluded (e.g. Fulé *et al.* 2003). This is a critical analytical component because the accuracy of the fire history is greatly strengthened as a result.

The following analyses were based on the 104 samples with fire scar year data organised by decade. The influence of sample size on the number of fires that were detected at a site per decade was determined thus:

1) the fire incidence data for all individual trees at each of the 13 sites were reduced to the period in which all trees were present;

2) the number of fires within this period were summed for each tree;

3) within each site the mean number of fires was calculated for all combinations of 1 to n trees, where n = the number of trees sampled at the site;

4) the outputs from the previous stage of analysis were aggregated into one data set and the number of fires used as the dependent variable and the

size of the sample as the independent variable, in linear, quadratic and polynomial regression analyses;

5) the regression line with the highest R^2 (Minitab Inc. 2005) was used to derive a conversion factor for each level of sampling by dividing the number of fires predicted at the largest sample size by the number of fires predicted at the particular sample size.

This analysis accounts for the irregular number of samples, and therefore potential fire scars, from each site and results in an adjusted measure of fire frequency. All subsequent reference to adjusted data indicates this procedure. The adequacy of sample size must be used and interpreted with the knowledge that the output is essentially a function of the input, in this instance number of fires and number of samples. Different vegetation types will burn in different ways hence an adequate sample number for one area may be inadequate or excessive for another.

The fire scar record from the young trees from site SH12D which were used in the dendrochronological analysis in chapter 3 and the error calculations in chapter 4, were not included in these analyses. The sample size conversion would have been biased to an unrealistic level by the use of a subset of young trees sampled from a single site.

5.2.2.2 The effect of species composition

Were fire scars more prevalent in one eucalypt species than another? This question was addressed in two ways. Firstly, from the sample set of 104 trees, all trees > ~200 years were grouped according to species. Commencing with the decade of establishment, each decade of fire scar occurrence (1st – 20th) was recorded. Patterns in fire scar incidence for the resulting 20 decade period were analysed and contrasted for each of the seven sampled eucalypt species (Chapter 2 p.40). A spreadsheet example for six trees at one site (TO55H) is provided below (Table 5.2).

Years since establishment (decade)	TO55H1 (E. obl)	TO55H2 (E. obl)	TO55H3 (E. amy)	TO55H6 (E. amy)	TO55H7 (E.obl)	TO55H8 (E.obl)	No. of fires per decade
0-9 (1)	E	E	E	E	E	E	0
10-19 (2)			x			x	2
20-29 (3)							0
30-39 (4)							0
40-49 (5)							0
50-59 (6)				x			1
60-69 (7)					x		1
70-79 (8)							0
80-89 (9)		x	x				2
90-99 (10)				x			1
100-109 (11)							0
110-119 (12)						x	1
120-129 (13)		x				x	2
130-139 (14)							0
140-149 (15)						x	1
150-159 (16)						x	1
160-169 (17)						x	1
170-179 (18)					x		1
180-189 (19)		x	x			x x	4
190-199 (20)							0
Total	-	3	3	2	2	8	**18**

Table 5.2 shows a spreadsheet example of how the number of fires in each of 20 decades were calculated. E = establishment decade. Samples TO55H3 and 8 each recorded a fire scar in the decade following establishment, thus recorded with x in decade 2. Tree TO55H8 recorded 2 fires in decade 19. The first recorded fire scar after establishment for sample TO55H6 was in the 6th decade, and so on. TO55H1 was included because it was > 200 yrs old however, no fire scar was recorded in the first 20 decades after establishment. Sample TO55H5 does not appear in this table because it was not included in the tree age analysis because its age was < 200 yrs.

Secondly, a direct comparison of the number of fire scars from two species from the same sites for the same fires was made. There were only two species which co-occurred over enough sites to ensure adequate replication. These were *E. amygdalina*, a rough barked tree and *E. globulus*, a gum-barked tree. They occurred in sites MC21D, SH65A, AR, LSP, SHE, SW59C and SHU. The number of fire scars per tree recorded during the common period of 1850 – 1960 were tested for significant between-species differences using a two sample t-test and a Kruskall-Wallis U test.

5.2.2.3 The effect of tree age

The following four types of spreadsheet analyses test for the effects of tree age and account for any age bias in the fire scar record:

1) As for the previous analysis, the number of fire scars on each tree > 200 years was summed into decade of occurrence for 20 decades and graphed. An example of this calculation is shown in Table 5.2 for those trees > 200 yrs from site TO55H. Patterns of fire scar distribution according to tree age subsequently became detectable.

2) Periods of distinctly different fire frequencies were evident from the composite fire scar data. The periods are:

   1740 – 1820
   1820 – 1850
   1850 – 1910
   1910 – 1990
   1990 – 2004

Within each of the periods, the number of fires recorded on each individual > 200 years old throughout the period was regressed against the age of the individual at the end of the period.

5.2.2.4 *The effect of other variables*

Landscape position (1 = ridgetop or upper slope, 2 = midslope, 3 = other such as on the edge of a drainage depression) was noted, bark thickness (mm) and diameter (dob mm) were measured with a tape, elevation (m asl) was recorded from a gps and corrected from a 1:25,000 topographic map, and slope (^{0}) was determined with a clinometer. Landscape position and the number of fire years recorded in each individual tree were analysed in Minitab (Minitab Inc. 2000) using one-way ANOVA and the other continuous variables were tested using Pearson's correlation to determine if these attributes were related to fire injury susceptibility and or distribution.

5.3 *Results*

All reported dates or years are estimations and are qualified by the error margins calculated in the previous chapter. Adequate sample size may fluctuate in different locations or landscapes due to the nature of individual fires. The following results are thus qualified because low intensity, patchy or very small fires may not be captured using the methods described here.

5.3.1 Sample size effect

The cumulative sample size curve indicated that 9 - 10 samples per site were adequate (Fig 5.1). The sample size conversion ratios used in this calculation appear below (Table 5.3). The equation was:

= -0.1399*sample size*sample size+3.3416*sample size+1.284 (r^2 = 0.8341)

N	Conversion Factor
1	5.388
2	2.957
3	2.157
4	1.764
5	1.533
6	1.383
7	1.279
8	1.204
9	1.148
10	1.106
11	1.073
12	1

Table 5.3 Details of conversion used to calculate adjusted number of fires per decade.

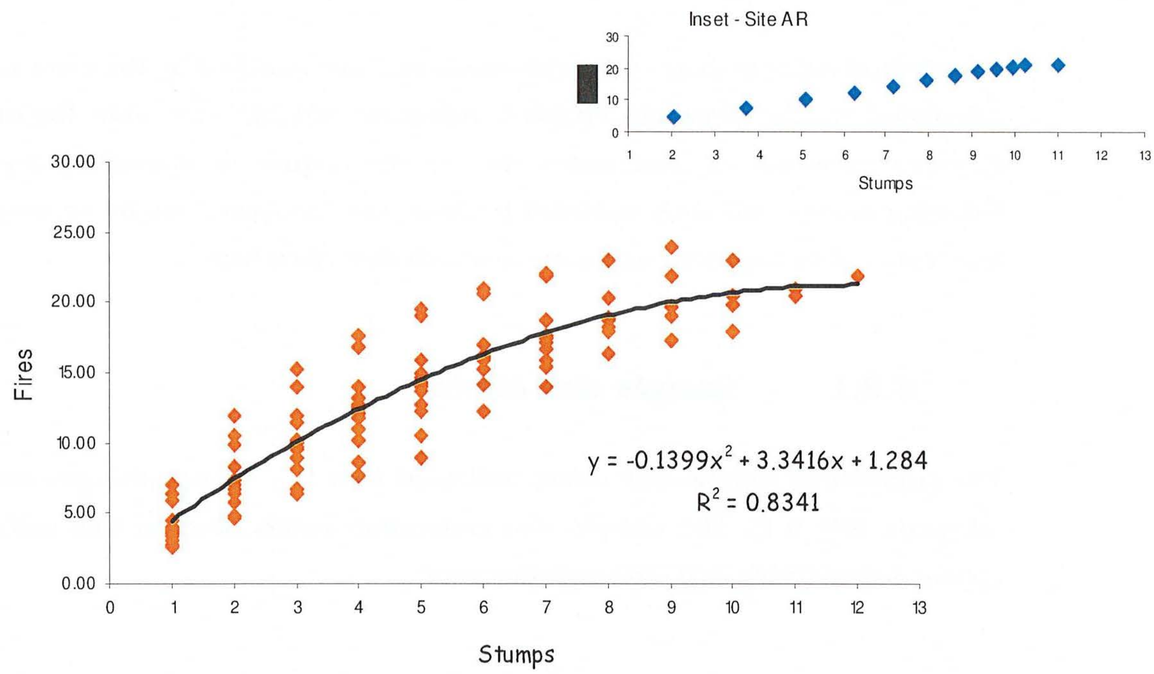


Fig. 5.1 Cumulative sample size polynomial curve provided the best fit. Detected fire scars began to stabilise after 9-10 samples.

5.3.2 Tree age effects

5.3.2.1 Tree age in relation to distinctly different periods

Trees > 200 years (n=66) had higher numbers of fire scars as they got older (Table 5.4, Fig. 5.2). Estimated tree age was positively related with total fires per stump initially indicating that older trees carried more fires.

Aggregated fire scars on stumps > 200 years (n = 66)

Decades	TO52B (n = 7)	TO55H (n = 6)	MC21D (n = 2)	SH12D (n = 7)	SH65A (n = 6)	W (n = 5)	Q (n = 10)	SHE (n = 1)	SW59C (n = 4)	LSP (n = 7)	AR (n = 5)	SHU (n = 6)
1	0	0	1	1	0	0	1	0	0	0	0	1
2	2	2	0	1	2	0	1	0	0	1	1	0
3	3	0	0	3	0	0	0	0	0	2	1	2
4	2	0	0	0	0	0	1	0	0	0	0	0
5	1	0	0	0	1	1	0	0	1	1	1	1
6	0	1	0	0	1	1	2	0	0	0	1	1
7	0	1	0	0	0	0	2	0	0	1	0	1
8	0	0	0	1	0	0	1	0	0	0	0	0
9	0	2	0	0	1	0	2	0	0	2	0	1
10	0	1	0	0	1	2	3	1	1	1	1	0
11	2	0	0	0	1	0	1	0	0	1	3	2
12	0	1	0	0	0	1	0	0	1	2	3	0
13	0	2	1	0	0	1	1	0	1	2	1	0
14	2	0	0	1	1	0	4	0	4	2	2	2
15	2	1	1	0	0	3	2	0	3	2	2	3
16	4	1	1	1	0	3	3	0	3	5	3	1
17	1	1	0	1	0	1	2	0	4	1	0	2
18	4	1	1	1	0	3	3	1	5	1	3	1
19	1	4	1	1	1	0	4	0	3	1	2	1
20	5	0	1	1	1	0	2	0	3	2	1	2
Totals	29	18	7	12	10	16	35	2	29	29	25	21

Table 5.4 Trees which were included in the analysis (> 200 years old). From the first decade of establishment to the 20th the number of fire scars appear to increase within most trees.

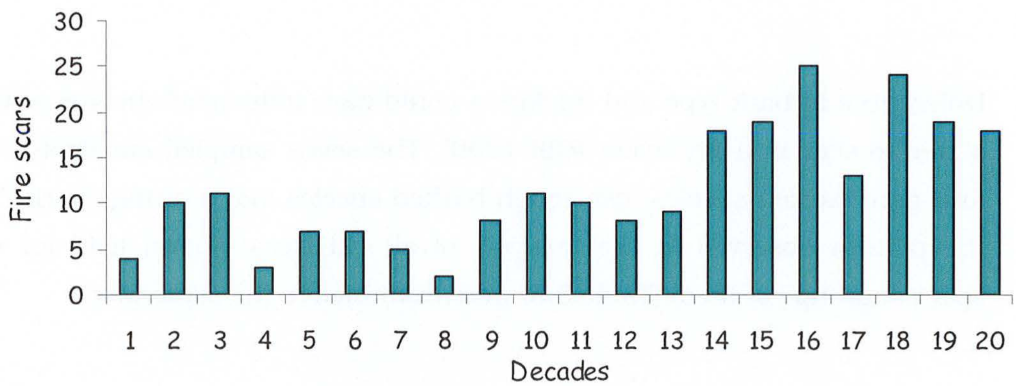


Fig. 5.2 Number of fire scars recorded in all trees > 200 years by age (n=66).

The observation from these analyses assumes that there was no temporal variation in fire incidence due to causes other than age, as most trees > 200 years were young prior to European settlement (1802) and old in the 20th Century. When the age of trees in 1990 was regressed against the number of fire scars in the period 1910 – 1990 there was no significant relationship (DF = 1, F = 4.0774, r^2 = 0.0617, P = 0.0478). The same pertained for the age of trees in 1910 when regressed against the number of fires in the period 1850 – 1910 (DF = 1, F = 0.6224, r^2 = 0.0101, P = 0.4332) and in the periods 1820 – 1850 (DF = 1, F = 0.0881, r^2 = .0014, P = 0.7673) and before 1820 (DF = 1, F = 3.356, r^2 = 0.0522, P = 0.0718). These results indicate that factors other than age caused the pattern in Fig 5.2.

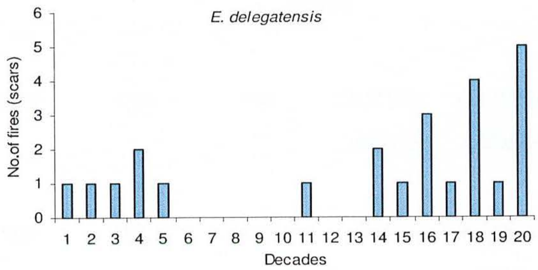
5.3.2.2 *Effect of species on age and propensity for fire scar susceptibility*

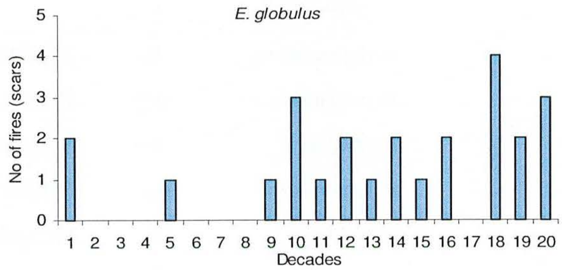
Differences in bark type and thickness could have influenced the susceptibility of a tree to scar in a fire event (Gill 1990). The seven sampled eucalypts comprise four gum barked species, two rough barked species and a stringy bark. To see if the pattern observed in the analysis of all old trees (above) held for different species, groups of them (Table 5.5) were examined in the same way.

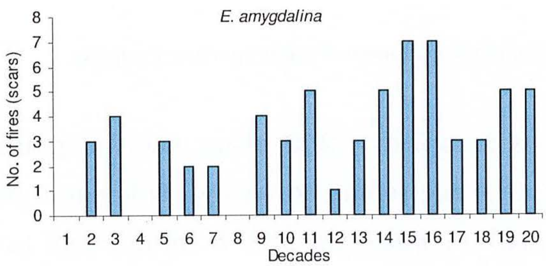
Species	n	Sites					
E. delegatensis	5	TO52B					
E. amygdalina	20	TO55H	MC21D	SW59C	SP	AR	SH
E. obliqua	8	TO55H	SH65A	SW59C			
E. tenuiramis	6	SH12D					
E. globulus	8	MC21D	SH65A	SHE	SHU	LSP	AR
E. pulchella	3	AR	LSP				
E. dalrympleana	16	TO52B	W	Q			

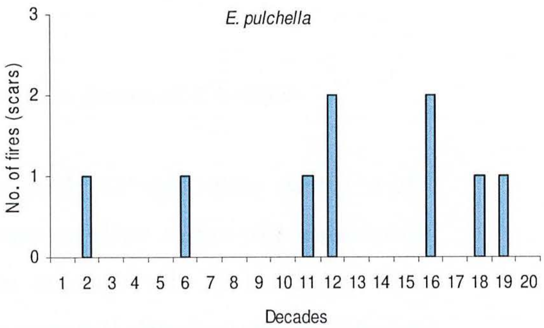
Table 5.5 Summary of numbers of trees and sites of each species grouping.

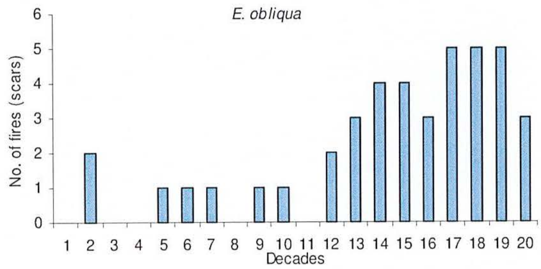
There were only five *E. delegatensis* samples > 200 years yet the pattern of increasing fire scars with increasing tree age remained strong. This same pattern held for each of the species although *E. pulchella* and *E. tenuiramis* are not strictly consistent with the pattern demonstrated in the other graphs possibly due to low numbers of them in the analysis (Fig 5.3).

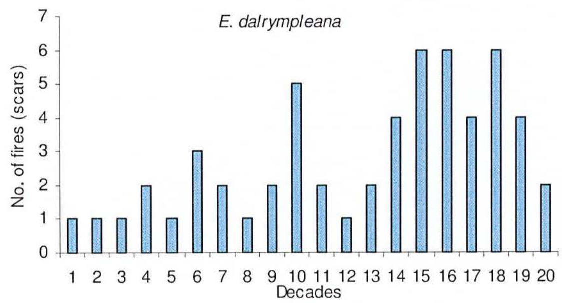












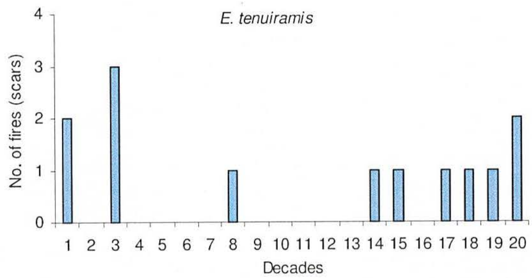


Fig 5.3 Depiction of fire scar distribution on trees > 200 yrs old.

Fire scars recorded from *E. amygdalina* (n = 28, mean age = 175: range 114 - 256) and *E. globulus* (n = 19, mean age = 174: range 112 - 238) from seven sites between 1850 – 1960 were not statistically different (two sample t: p = 0.014; H = 8.87, DF = 6, p = 0.181) indicating that differences between these two species did not influence the fire scar data.

5.3.3 Other variables

The Pearson' correlation analysis dismissed any relationship between number of fire scars and the four continuous variables (Bark thickness p = 0.768; DOB p = 0.476; Slope p = 0.447; Elevation p = 0.368). Landscape position was significant (p = 0.002) indicating that trees on mid-slopes and hill-tops were less likely to recorded a fire than those lower in the landscape (Table 5.6 and Fig 5.4). Approximately 57% of trees were recorded in class 2, 26% in class 1 and 17% in class 3. One sample, SW59C5, recorded 16 separate fire scars. The most fire years (24) were recorded from this site and all individuals were recorded in position C, skewing the data.

Variable	DF	F	P	S	R^2	R^2 adj	Pooled St.dev	MS Error
Landscape position	2	6.4	0.002*	2.330	11.25%	9.49%	2.330	5.43

Table 5.6 ANOVA results showing the influence of Landscape position on fire scars per tree using data from all trees over all sites. * significant at < 0.005.

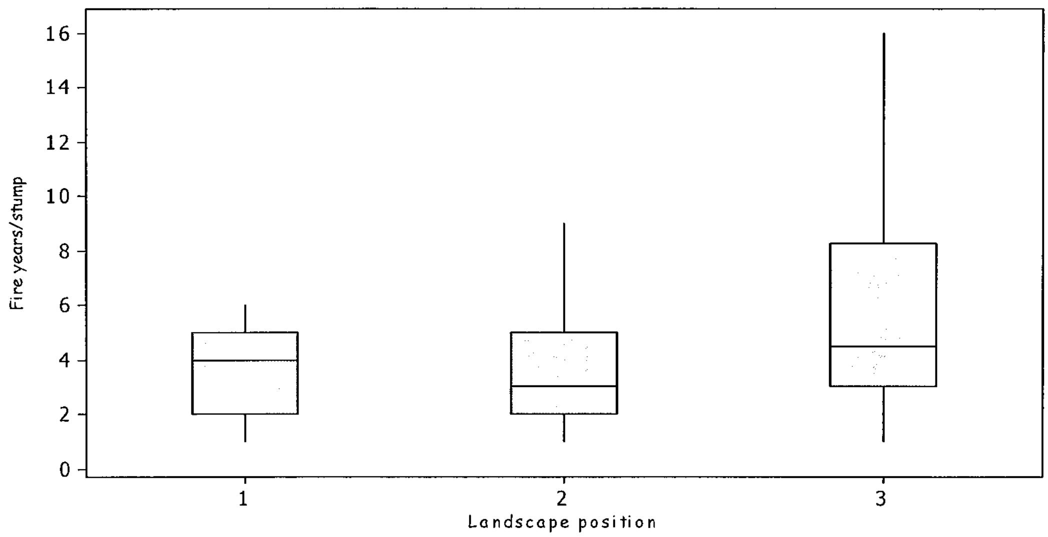


Fig 5.4 Boxplot showing more fire scars were recorded in trees in lower landscape positions with SW59C data included.

When site SW59C was removed, there was no significant relationship between landscape position and number of fire scars (p = 0.590).

5.4 *Discussion and Conclusions*

The sample size conversion procedure compensated for variable sample numbers and provided a guide to the most appropriate sample size for future studies of this nature. However, the procedure is not necessarily transportable because in different locations and landscapes the climate, landforms and ignition sources may alter the nature of fires requiring greater or lesser sample numbers to adequately capture the fire record.

When the data fire scar set was reduced to trees that were greater than 200 years old and the total number of fires in each decadal age class summed, there was a strong pattern which indicated that older trees might be more susceptible to injury than young trees (Fig 5.2.) This was not unexpected given the observed 'halo' effect of fuel accumulation in the vicinity of old eucalypts which may predispose them to recording scars in a fire over younger trees without such fuel in close proximity (Banks 1982; Gibbons & Lindenmayer 2003).

However, older trees did not necessarily readily record more fires due to the proximity of solid fuel loads because the distinctly different period analysis of fire scar distribution shows that as the trees aged they experienced more fires because more fires occurred.

Neither the gum-barked *E globulus* or the rough-barked *E. amygdalina* were shown to have recorded significantly different numbers of fire scars throughout the 110 year period of common *n*. The experiments of Gill & Ashton (1968) and Gill (1974) indicate that *E. amygdalina* could be predisposed to record more fire scars than *E. globulus* due to its rough, more flammable bark. This was shown not to be the case.

The correlation analyses accounted for effects of environmental or tree property influences on fire scar distribution within and between trees and sites. Potentially, the effects of bark thickness, tree diameter, elevation, landscape position and slope could affect the propensity for a tree to record a fire scar. When site SW59C landscape position data were removed from the ANOVA analyses, none of these variables were shown to influence the fire scar data.

It should be noted that univariate analyses provided insight into simple relationships between two variables. Multivariate analyses, which could potentially have provided a more detailed understanding of the relationships between dependent variables were unable to be performed at the site level due to low sample numbers. Therefore, the pooling of data across all 13 sites, whilst limited in interpretative capacity, nevertheless provided an alternative way of discerning bias which was shown to be effective, as described above.

The analyses in this chapter have shown that there is a pattern of increasing numbers of fire scars with the passage of time which are unrelated to tree attributes, age or sampling. The next chapter explores the temporal and spatial patterns in the fire scar data.

Chapter 6

Temporal and spatial patterns of the fire regime

6.1 Introduction

The previous chapters have shown that ring counts for eucalypts in this study area are reliable.

This chapter describes spatio-temporal patterning in fire scar incidence and some of the relationships of these patterns with variation in rainfall.

6.2 Methods

The methods used to derive the data presented in this chapter are largely described in Chapters 2 and 5. Temporal arrangement of the fire scar data is presented in three separate ways:

Fire scar data were adjusted by the sample size formula described in chapter 5. The adjusted number of fires per decade per site was calculated for all decades where there were samples from more than two sites. Although there were fire scars recorded prior to 1740, they occurred on trees from only one site (TO55H). Using the conversion factor, Table 5.3 in section 5.3.1, the resulting adjusted number of fire years were divided by the number of decades to establish a mean decadal number of fire years. An example of the data used in this process appears for site AR in Table 6.1. The mean number of fires recorded in each decade were thus obtained for each of the 13 sites. The mean number of fire years was calculated from the first to the last recorded fire for each site to ensure the best replication of fire dates.

decade	n	site fire years	factor	adjusted fire years per decade
2000-2004	12	-	-	0.0
1990-1999	12	1996	1	1.0
1980-1989	12	1980 1985	1	2.0
1970-1979	12	1972 1976	1	2.0
1960-1969	12	1965	1	1.0
1950-1959	12	1952	1	1.0
1940-1949	12	1948	1	1.0
1930-1939	12	1932 1938	1	2.0
1920-1929	12	1924 1927	1	2.0
1910-1919	12	1912	1	1.0
1900-1909	12	1903	1	1.0
1890-1899	10	1893	1.106	1.1
1880-1889	10	1885	1.106	1.1
1870-1879	10	-	-	0.0
1860-1869	10	1866	1.106	1.1
1850-1859	10	1856	1.106	1.1
1840-1849	10	-	-	0.0
1830-1839	10	1835	1.106	1.1
1820-1829	8	1821	1.204	1.2
1810-1819	6	1814	1.383	1.4
1800-1809	6	-	-	0.0
1790-1799	6	1795r?	-	0.0
1780-1789	3	1786r?	-	0.0
1770-1779	1	-	-	-
1760-1769	1	-	-	-
1750-1759	1	-	-	-
1740-1749	0	-	-	-

Table 6.1 Data used in the process of utilising the sample size factor shown for site AR. The number of fire years for each site was adjusted by the relevant factor according to sample n. This reduced the fire scar data to *x* number of fires per decade without reference to a particular year. r? = possible regeneration fire.

The adjusted fire scar data were aggregated and arranged into decades. Mean decadal fire scar frequency data were visually examined for distinct breaks in sequence with eras or periods, allocated accordingly. While this chapter reports on the delineation of eras, explanations for these breaks in the data in relation to land use and cultural practices are offered in the next chapter.

Site chronologies were generated from the individual tree fire scar chronologies the methods of which are described in section 2.4.6.1. A composite chronology was derived for each site as described in section 2.4.6.2. While not cross-dated, these chronologies are nevertheless depicted using an adaptation of the format reported in Arno & Sneck (1977) and refined by Grissino-Mayer (1995). This format renders the fire scar information eminently readable and renders the widespread nature of fire scars in some years easily discernable (e.g. 1966).

Spatial patterns in the unadjusted fire year data were observed through the construction of a mean annual rainfall gradient. A link was demonstrated between years of low rainfall and a regional fire year when the same fire year was identified across several sites.

Mean annual rainfall records were used to establish a link between the fire scar data and fire extent by identifying potential widespread fire years. The datasets of monthly rainfall for Lake Leake (1890-2004), Cranbrook (1901-2004) and Buckland (1909-2004) were combined, converted into standard deviations and compared with Hobart (1890-2004), similarly converted, to establish synchrony. The three study area climate stations are representative of the range of elevation throughout the Eastern Tiers. The highest is at Lake Leake (522 m asl.), mid elevation is at Cranbrook (398 m asl.) and one of the lowest is at Buckland (230 m asl.) (Fig 6.1).

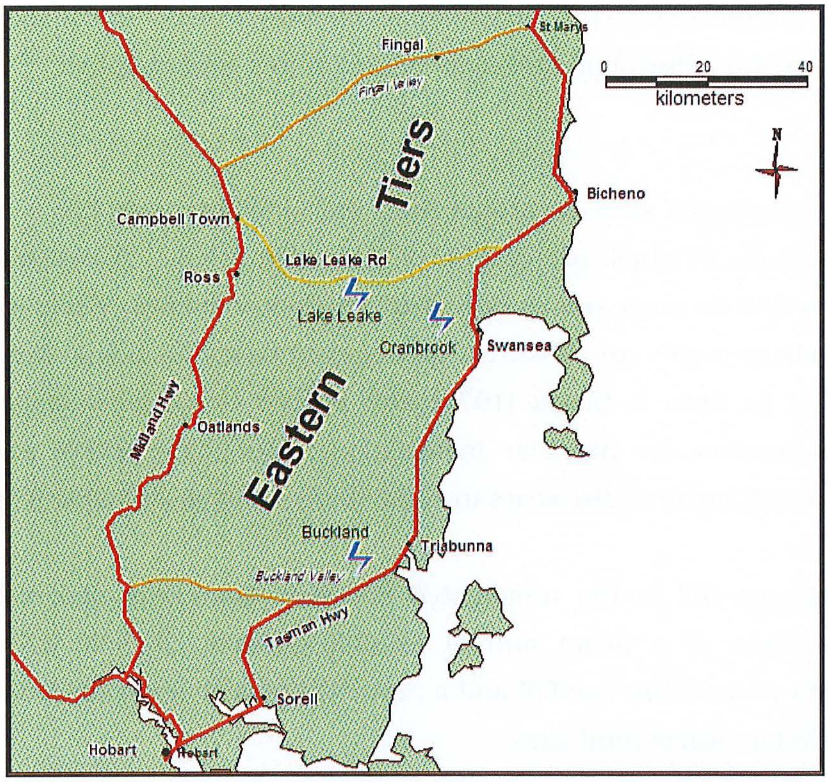


Fig 6.1 Rainfall stations were representative of high (Lake Leake), mid (Cranbrook) and low (Buckland) elevation areas in the study area and are indicated thus .

The similarity of rainfall patterns between Hobart and the three combined Eastern Tiers datasets from 1890 to 2004 determines the usefulness of using the Hobart dataset, 1855 – 1890, as a proxy for Eastern Tiers rainfall where no records prior to 1890 are available, in order to extend the rainfall record. Regression analysis of the combined Eastern Tiers rainfall data against Hobart rainfall data and Pearson's correlation between the same two datasets was used to test for similarity in this regard. Low annual rainfall was defined as occurring in those years falling more than one SD below the mean.

It is difficult to extrapolate fire size from point based fire scar data (Agee 1993). However, widespread fires throughout the study area were inferred from synchronous fire years. Where the same fire year was evident across *three* or more of the 13 sites, the event was considered to be potentially regional. In one instance, four sites each recorded two fire years within one year of each other (1803/04) and were also counted as a potentially regional event. Potential widespread fire years were thus determined and tabulated.

From the rainfall dataset, all years which fell into one of two classes were identified:

- -1 s.d.
- -.75 s.d. - -1 s.d.

The tabulated widespread fire years either matched a year in one of the above classes or did not.

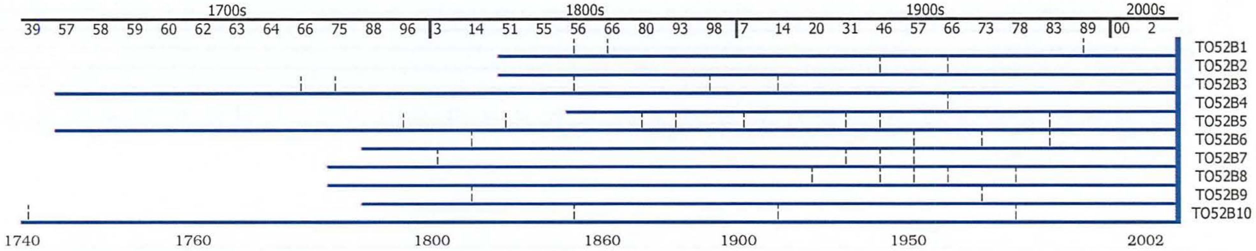
6.3 Results

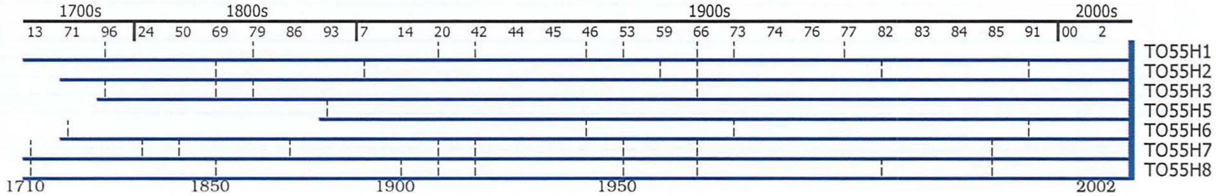
6.3.1 Temporal patterns

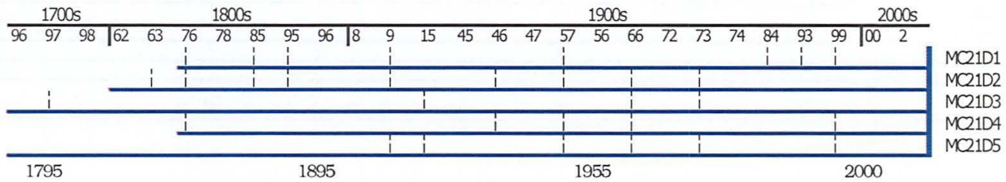
6.3.1.1 Fire scar chronologies

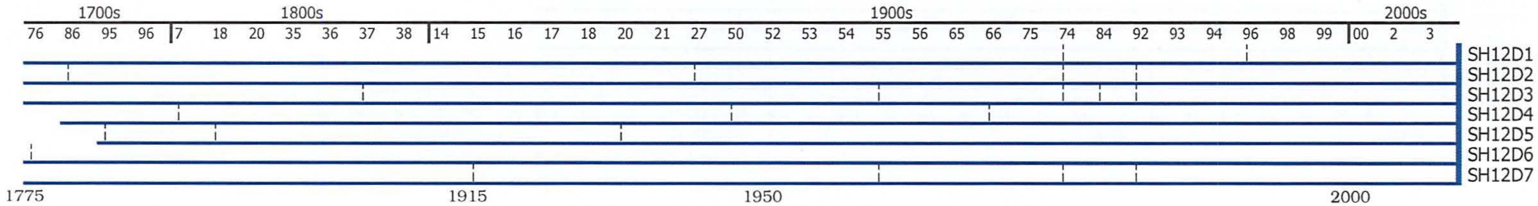
Since the data reported here have not been adjusted by the sample size formula, the usefulness of these plots relates to observations in support of temporal fire scar spread (Table 6.1) and distribution of fire scars in distinctly different periods (Table 6.2 and Fig. 6.5). These periods have been identified thus:

1740 – 1820: 1820 – 1850: 1850 – 1910: 1910 – 1990: 1990 – 2004.


1700s
1800s
1900s
2000s
39 57 58 59 60 62 63 64 66 75 88 96 3 14 51 55 56 66 80 93 98 7 14 20 31 46 57 66 73 78 83 89 00 2
TO52B1
TO52B2
TO52B3
TO52B4
TO52B5
TO52B6
TO52B7
TO52B8
TO52B9
TO52B10
1740 1760 1800 1860 1900 1950 2002


1700s
1800s
1900s
2000s
13 71 96 24 50 69 79 86 93 7 14 20 42 44 45 46 53 59 66 73 74 76 77 82 83 84 85 91 00 2
TO55H1
TO55H2
TO55H3
TO55H5
TO55H6
TO55H7
TO55H8
1710 1850 1900 1950 2002


1700s
1800s
1900s
2000s
96 97 98 62 63 76 78 85 95 96 8 9 15 45 46 47 57 56 66 72 73 74 84 93 99 00 2
MC21D1
MC21D2
MC21D3
MC21D4
MC21D5
1795 1895 1955 2000


1700s
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2000s
76 86 95 96 7 18 20 35 36 37 38 14 15 16 17 18 20 21 27 50 52 53 54 55 56 65 66 75 74 84 92 93 94 96 98 99 00 2 3
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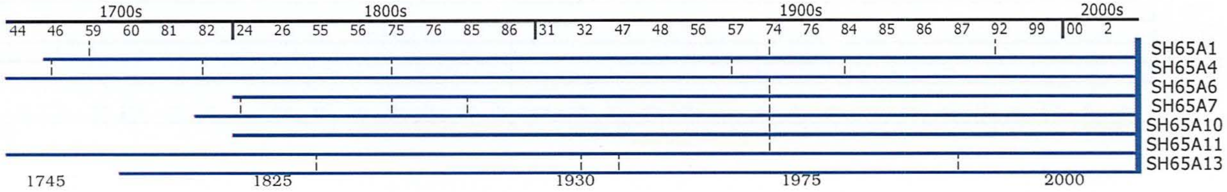
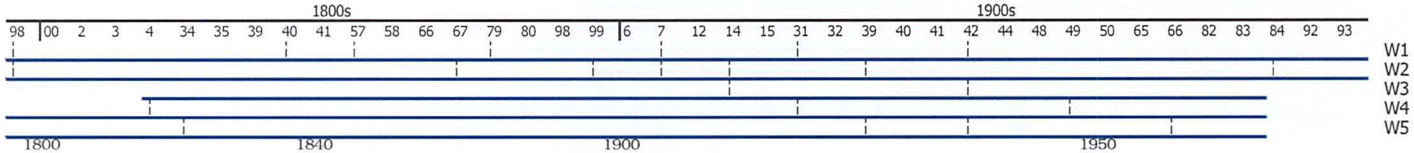
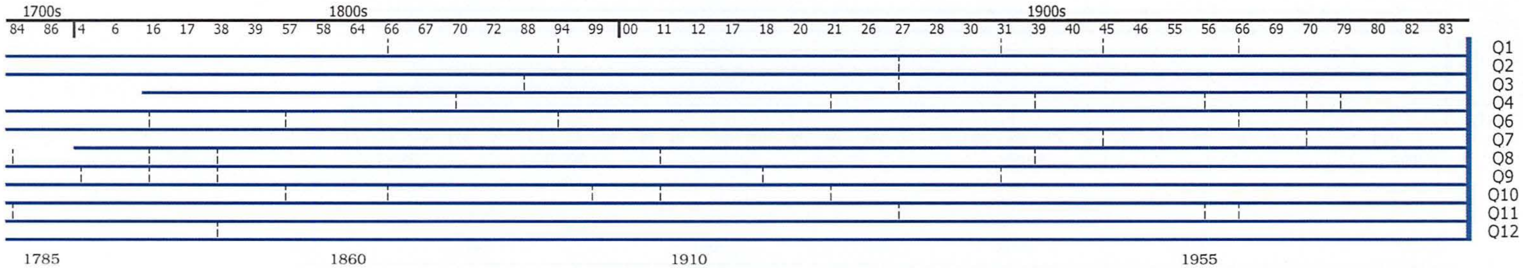
SH12D2
SH12D3
SH12D4
SH12D5
SH12D6
SH12D7
1775 1915 1950 2000


1700s
1800s
1900s
2000s
SH65A1
SH65A4
SH65A6
SH65A7
SH65A10
SH65A11
SH65A13
1745
1825
1930
1975
2000


1800s
1900s
W1
W2
W3
W4
W5
1800
1840
1900
1950


1700s
1800s
1900s
Q1
Q2
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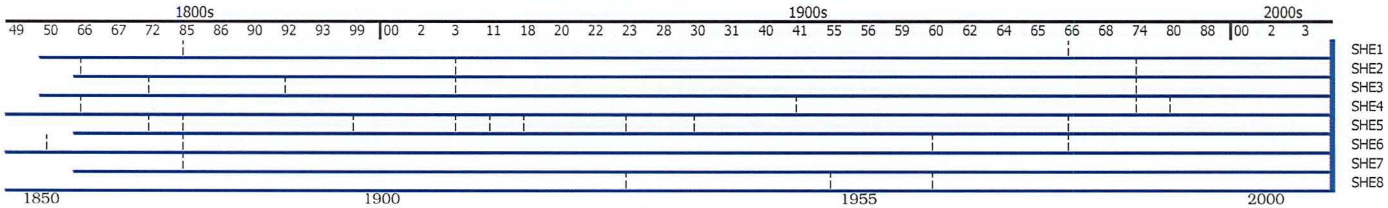
Q4
Q6
Q7
Q8
Q9
Q10
Q11
Q12
1785
1860
1910
1955


1800s
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SHE1
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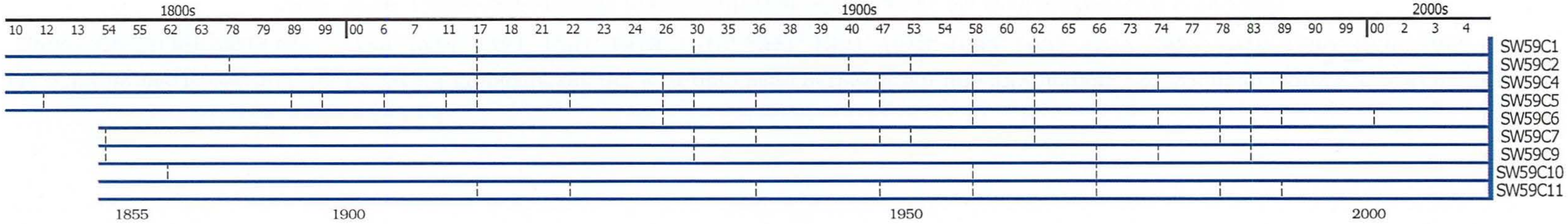
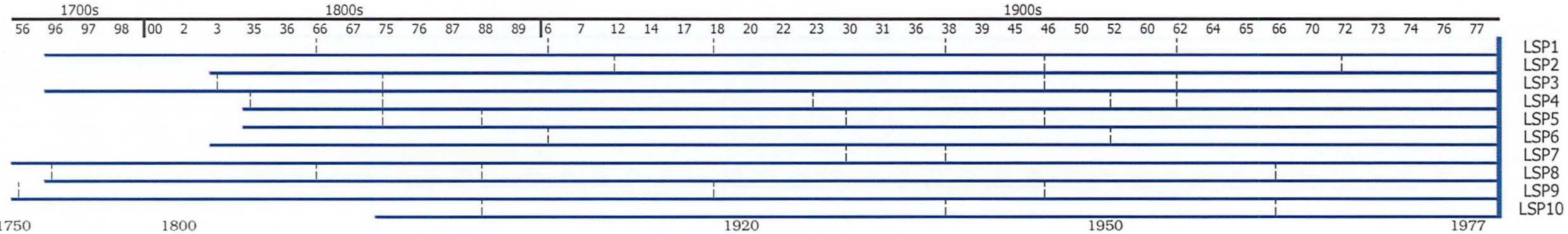
SHE8
1850
1900
1955
2000


1800s
1900s
2000s
10 12 13 54 55 62 63 78 79 89 99 00 6 7 11 17 18 21 22 23 24 26 30 35 36 38 39 40 47 53 54 58 60 62 65 66 73 74 77 78 83 89 90 99 00 2 3 4
SW59C1
SW59C2
SW59C4
SW59C5
SW59C6
SW59C7
SW59C9
SW59C10
SW59C11
1855
1900
1950
2000


1700s
1800s
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56 96 97 98 00 2 3 35 36 66 67 75 76 87 88 89 6 7 12 14 17 18 20 22 23 30 31 36 38 39 45 46 50 52 60 62 64 65 66 70 72 73 74 76 77
LSP1
LSP2
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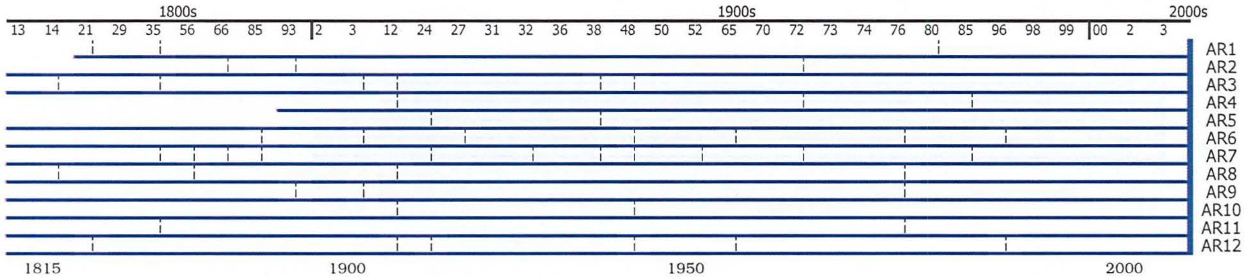
1750
1800
1920
1950
1977


1800s
1900s
2000s
13 14 21 29 35 56 66 85 93 2 3 12 24 27 31 32 36 38 48 50 52 65 70 72 73 74 76 80 85 96 98 99 00 2 3
AR1
AR2
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AR7
AR8
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AR10
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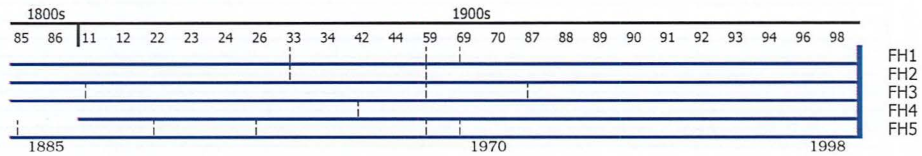
AR12
1815
1900
1950
2000



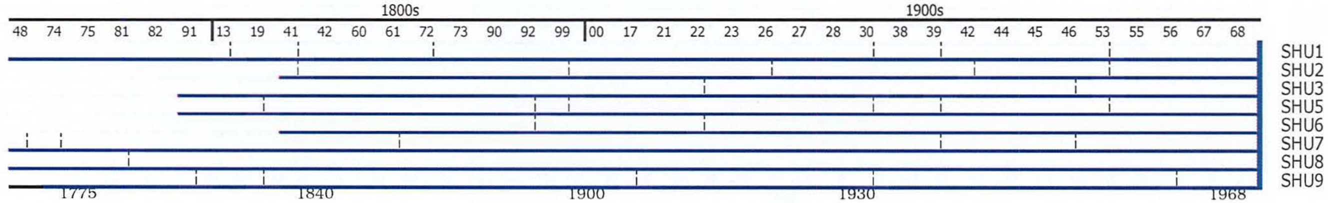


Fig 6.2 Samples for each of the 13 sites. Composite site fire scar data were derived from this information. For example, using site SHU immediately above, the 20 fire years were: 1748, 1774, 1781, 1791, 1813, 1819, 1841, 1861, 1872, 1892, 1899, 1917, 1922, 1926, 1930, 1939, 1942, 1946, 1953, 1956. ¦ = fire scar directly underneath year of formation. No year is presumed to be exact.

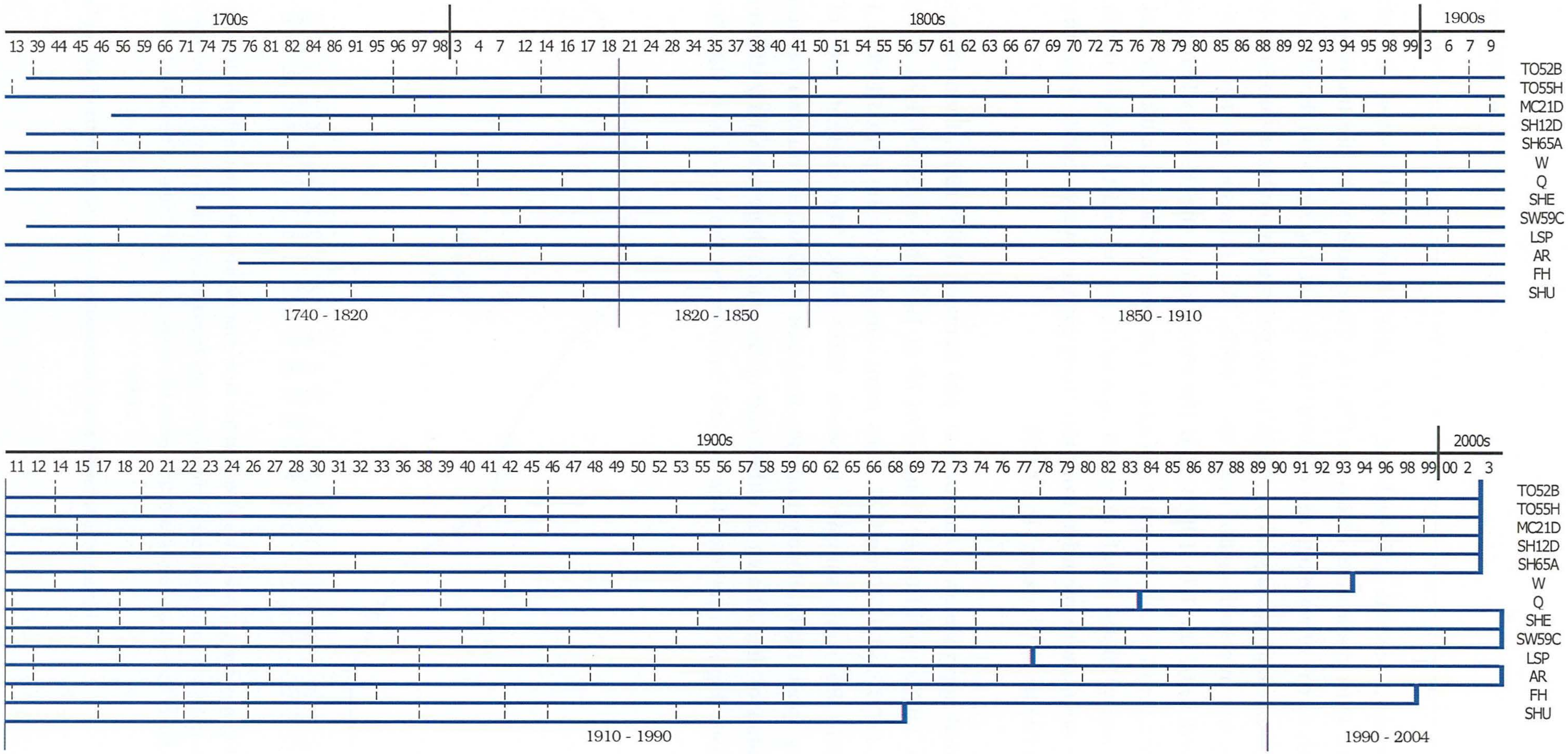


Fig. 6.3 Composite fire scar chronology for the 13 sites showing delineated distinctly different periods.

The summed, decadal adjusted fire scar data, from all 13 sites, are plotted against n, with respective scales, in Fig 6.4. Fluctuations in fire incidence over the length of the chronology are evident and do not appear to be directly related to n in the pre European years. A peak in fire years is apparent around the 1800s which is not reached again until the 1850s. An increase in fire years was maintained until the late 1980s with the exception of the 1910s when a sharp drop in fire years occurred over most sites. Fire scar incidence markedly drops off after the early 1990s which does not appear to be related to sample depth (Fig 6.4). Fire scars were recorded from the study area in every decade from the first recorded fire in 1713, except the 1720s.

N remained approximately constant at 104 between 1879-1969, then dropped to 96 in the 1970s, and further reduced to 70 at 1990. N decreased from 104 to 63 between 1800 and 1750 and 27 trees were sampled for the period before 1750. There were 85 trees sampled between 1800-1850. The current rate of fire frequency (post 1990) closely matches that pre 1820 where number of samples and number of fires shown at either end of the chronology are vastly different. It is therefore highly unlikely that n and number of fire years are significantly related.

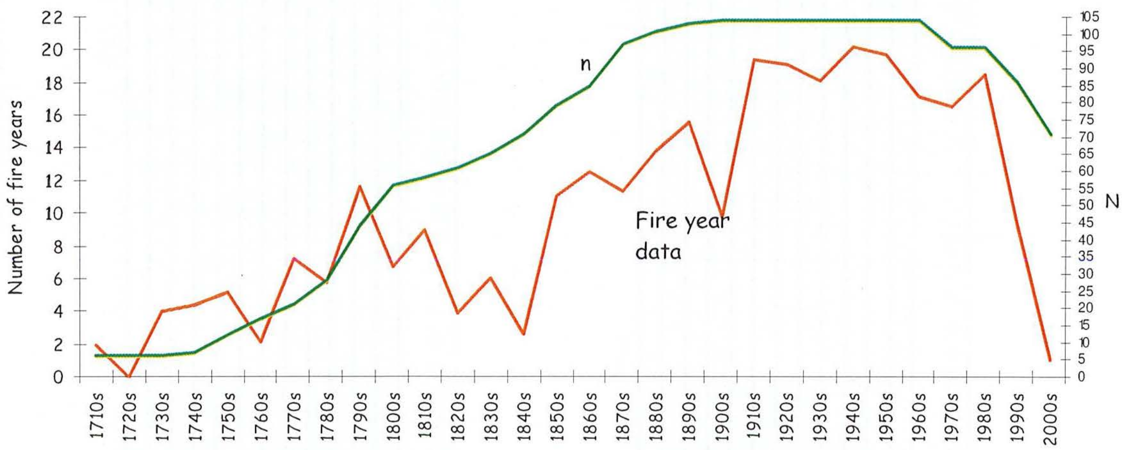


Fig. 6.4 Composite adjusted mean decadal fire scar data shown with sample depth. Increasing sample numbers did not necessarily show increased fires indicating that n and the fire year data are not related. The chronology spans 287 years but there is a low number of recorder trees before 1740.

There were distinct breaks in the aggregated mean decadal fire year data (1740 – 2004) at around 1820, 1850, 1910 and 1990 (Table 6.2). These breaks, and their rationale, are briefly described below and are shown by highlighting in Table 6.2.

The eight decades between 1740 - 1820 show high between-decade variability (range 0.3 – 1 fire years per decade) with six of them occurring prior to European settlement of Tasmania in 1803. Many trees did not record fire scars for successive decades during this period.

The decade commencing 1820 shows a contrasting drop in fire years which is sustained at a low rate for three decades. These decades are characterised by very low mean decadal fire years (range 0.2 – 0.5) indicating a clear shift in the pattern from the earlier decades. Many trees, otherwise recording fire scars, did not record any for two or three of these decades.

A very large increase in fire years occurs at around 1850 and the comparatively high rate of recorded fire years was sustained until 1910 (range 0.8 – 1.2). This group is distinctively different from the earlier one. The first decade of the 1900s showed an average 0.8 fire years where fire scars were not detected from sample trees across five sites. This decade is clearly delineated from those which follow and appears to align more closely with the preceding 6 decades.

Fire years increased substantially during the 1910s. The mean decadal fire years in the period 1910 – 1989 (range 1.3 – 1.7) are distinctly different from those of the preceding or following decades.

A reduction in fire years in the 1990s delineates this and the four years of the 2000s from the eight earlier decades and forms the most recent period.

Mean adjusted decadal fire years by site														
Decade	TO52B	TO55H	MC21D	SH12D	SH65A	W	Q	SHE	SW59C	LSP	AR	FH	SHU	**Mean decadal fire years**
2000-2004	0.0	0.0	0.0	0.0	0.0	-	-	0.0	1.1	-	0.0	-	-	**0.1**
1990-1999	0.0	1.3	3.1	2.6	1.3	-	-	0.0	0.0	-	1.0	0.0	-	**1**
1980-1989	2.2	2.6	1.5	1.3	1.3	1.5	0.0	2.4	2.3	-	2.0	1.5	-	**1.7**
1970-1979	2.2	2.6	1.5	1.3	1.3	0.0	1.1	1.2	2.3	1.1	2.0	0.0	-	**1.4**
1960-1969	1.1	1.3	1.5	1.3	0.0	1.5	1.1	2.4	2.3	2.2	1.0	1.5	0.0	**1.3**
1950-1959	1.1	2.6	1.5	2.6	1.3	0.0	1.1	1.2	2.3	1.1	1.0	1.5	2.4	**1.5**
1940-1949	1.1	2.6	1.5	0.0	1.3	3.1	1.1	1.2	2.3	1.1	1.0	1.5	2.4	**1.6**
1930-1939	1.1	0.0	0.0	0.0	1.3	3.1	1.1	1.2	2.3	2.2	2.0	1.5	2.4	**1.4**
1920-1929	1.1	1.3	0.0	2.6	0.0	0.0	2.1	1.2	2.3	1.1	2.0	3.1	2.4	**1.5**
1910-1919	1.1	1.3	1.5	1.3	0.0	1.5	2.1	2.4	2.3	2.2	1.0	1.5	1.2	**1.5**
1900-1909	1.1	1.3	1.5	0.0	0.0	1.5	0.0	1.2	1.1	1.1	1.0	0.0	0.0	**0.8**
1890-1899	2.2	1.3	1.5	0.0	0.0	1.5	2.1	2.4	1.1	0.0	1.1	0.0	2.4	**1.2**
1880-1889	1.1	1.4	1.5	0.0	1.3	0.0	1.1	1.2	1.1	1.1	1.1	1.8	0.0	**1**
1870-1879	0.0	1.4	1.5	0.0	1.3	1.5	1.1	1.2	1.1	1.1	0.0	0.0	1.2	**0.9**
1860-1869	1.1	1.4	1.8	0.0	0.0	1.5	1.1	1.2	1.1	1.1	1.1	0.0	1.2	**1**
1850-1859	2.2	1.4	0.0	0.0	1.3	1.5	1.1	1.4	1.1	0.0	1.1	-	0.0	**0.9**
1840-1849	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	-	1.2	**0.2**
1830-1839	0.0	0.0	0.0	1.3	0.0	1.5	1.1	0.0	0.0	1.1	1.1	-	0.0	**0.5**
1820-1829	0.0	1.4	0.0	0.0	1.3	0.0	0.0	-	0.0	0.0	1.2	-	0.0	**0.4**
1810-1819	1.3	1.4	0.0	1.3	0.0	0.0	1.1	-	1.1	0.0	1.4	-	1.4	**0.8**
1800-1809	1.3	0.0	0.0	1.3	0.0	1.8	1.1	-	0.0	1.3	0.0	-	0.0	**0.6**
1790-1799	1.3	1.4	3.0	1.3	0.0	1.8	0.0	-	0.0	1.5	0.0	-	1.4	**1**
1780-1789	0.0	0.0	-	1.4	1.5	0.0	1.1	-	0.0	0.0	0.0	-	1.8	**0.6**
1770-1779	2.2	1.5	-	1.8	0.0	0.0	0.0	-	-	0.0	-	-	1.8	**0.9**
1760-1769	2.2	0.0	-	0.0	0.0	0.0	0.0	-	-	0.0	-	-	0.0	**0.3**
1750-1759	0.0	0.0	-	0.0	2.2	0.0	0.0	-	-	3.0	-	-	0.0	**0.7**
1740-1749	-	0.0	-	-	2.2	0.0	0.0	-	-	0.0	-	-	2.2	**0.7**

Table 6.2 Adjusted mean fire frequency data table. Each site has a minimum of two trees recording fire scars in each decade. The mean frequency is calculated from the first to the last recorded fire for each site to ensure the best replication of fire dates. (0.0 = two or more trees but no recorded fire scars. - = either a single tree or no tree). Groupings of mean decadal fire years are similarly shaded in the last column.

When the average number of mean decadal fire years in each period is calculated, another temporal pattern emerges (Fig.6.5). There is similarity at 0.7, between the early period 1740 - 1820 and the latest period 1990 – 2004, albeit the latest period comprises 14 years and the earliest period, 80.

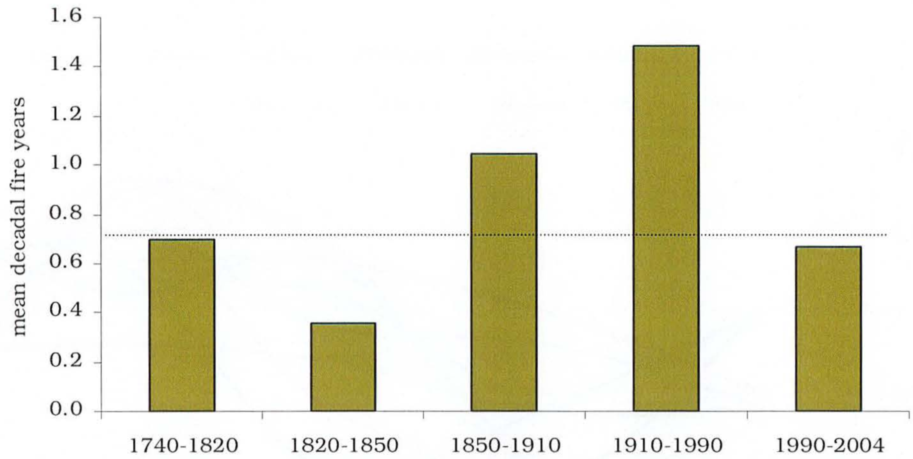


Fig. 6.5. Composite mean decadal fire years demonstrating the temporal pattern where the latest period 1990 – 2004, is closely aligned with the earliest period 1740 – 1820.

6.3.1.2 Patterns of site fire scar distribution

The visual pattern of fire scar frequency is very similar for most sites (Fig. 6.6). Site SH12D breaks from the established pattern and shows, along with site MC21D, a shift from less to more fire scars towards the end of the chronology. All other sites, except W, have a hiatus of firing between 1820 and 1850. Site W shows increased fire scars during this same period. Site MC21D demonstrates a departure in the pattern of fire scar distribution during the mid 20th C where few trees recorded fire scars resulting in an undulation which directly opposes those of the other sites (Fig 6.6).

The pattern of similarity of fire scar occurrence between the 13 sites raises the question of what might be driving such patterns?

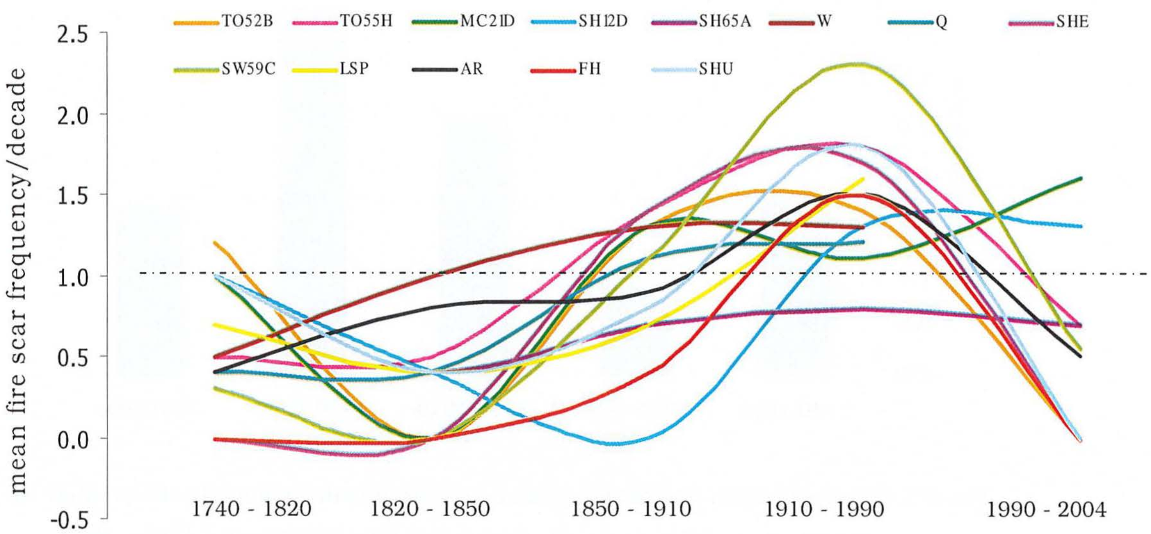


Fig 6.6 Pattern of composite mean decadal fire scar frequency through time clearly showing site similarity and individual site differences.

6.3.2 Patterns related to mean annual rainfall

The daily rainfall between Hobart (1890 - 2004) and three Eastern Tiers climate stations – Lake Leake, Cranbrook and Buckland (combined: 1890 - 2004) was highly correlated (r^2 = 0.811, P = 0.000). Therefore, daily rainfall from Hobart 1855 – 1890 was used as a proxy for Eastern Tiers precipitation which extended the record from 114 to 149 years (Fig 6.7). The plotted mean annual rainfall datasets visually show the compatibility between Hobart and Eastern Tiers precipitation (Fig 6.8).

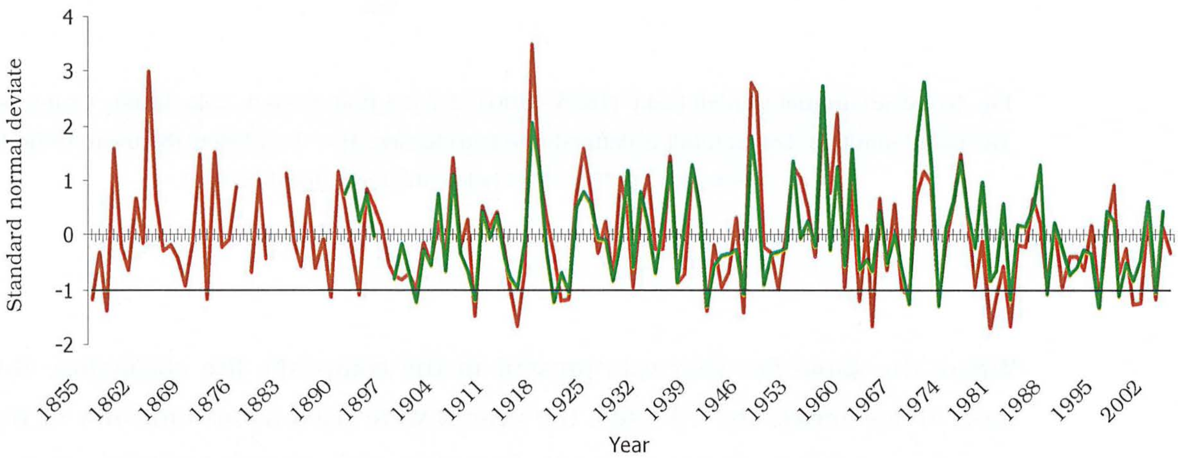


Fig. 6.7 Visual relationship between Hobart (brown line) rainfall 1855 – 2004 and the combined record (green line) of Lake Leake, Cranbrook and Buckland 1890 – 2004 (r^2 = 0.811, p = 0.000). Missing data occurs in years 1876, 1880, 1881, 1895 and 1896.

The two standard deviate classes (1) > -1 sd below mean, 2) > -0.75 < -1 sd below mean) and the low rainfall years falling into each are also evident in Fig 6.7.

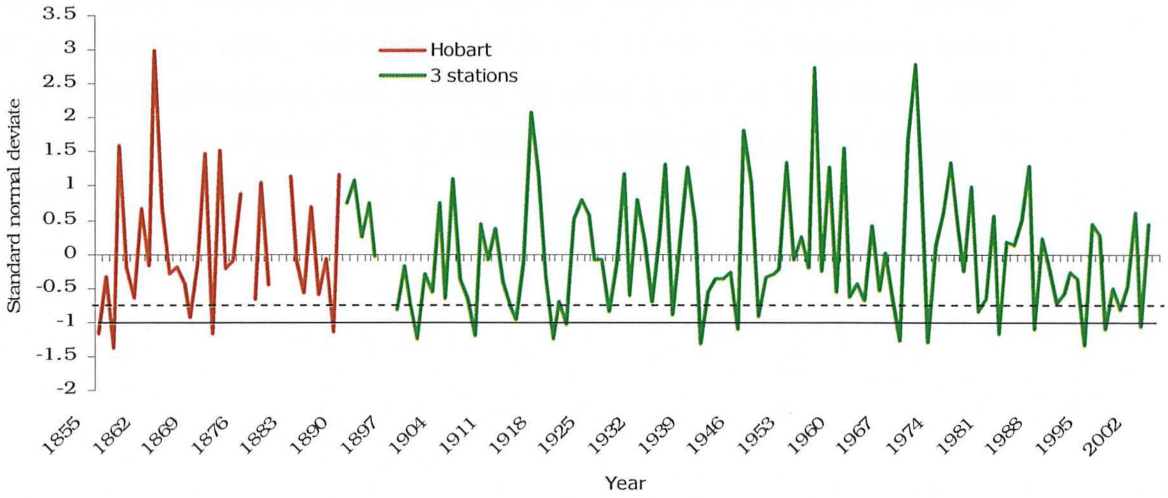


Fig. 6.8 Mean annual rainfall (s.d.) (1855 – 2004) derived from Hobart, Lake Leake, Cranbrook and Buckland stations. Low rainfall is defined into two classes, 1) > -1 sd below the mean (solid line) or between > -0.75 < -1 sd below the mean (dashed line).

Where the same fire year was present in the composite fire chronology three or more times across the 13 sites, the year/s were used as an indicator of regional or widespread fires. In one instance, four sites each recorded two fire years within one year of each other (e.g. 1803/04) and were included. Fire years were: 1796, 1803/4, 1814, 1857, 1866, 1885, 1893, 1899, 1907, 1911, 1915, 1918, 1920, 1922, 1926, 1930, 1938, 1942, 1946, 1953, 1956, 1966, 1973, 1974 and 1984 (Table 6.3). Three fire years (*) correlate to signal years derived from an East Coast cross-dated *Phyllocladus aspleniifolius* chronology (Allen 1998) (Table 6.3). Of the 25 widespread fire years four (#) exactly matched years < -.75 SD standard deviation below the mean (Table 6.3). There were no matches for years > -.75 SD < -1 SD.

In summary, seven fire years (29%) were found to exactly correlate to either low annual rainfall years or Tasmanian East Coast cross-dated narrow signal years (Table 6.3) which suggests a relationship between low annual rainfall and widespread fires. A further six years: 1857, 1899, 1938, 1942, 1974 and 1984, were matched to within one year of a low rainfall year from either of the two standard deviation classes.

Decade	**Rainfall years < -.75 SD**	**Rainfall years > -.75 SD < -1 SD**	**Widespread or regional fire years**	***Phyllocladus aspleniifolius* event years < -1 SD below mean**
1790-1799	n/d	n/d	1796	1790
1800-1809	n/d	n/d	1803/04	
1810-1819	n/d	n/d	**1814***	1814, 1816
1820-1829	n/d	n/d		1828
1830-1839				1834, 1834
1840-1849				1847, 1848
1850-1859	1856, 1858		1857^{+1}	1850
1860-1869	1869		1866*	1860, 1865, 1866, 1869
1870-1879	1872			1873
1880-1889	1889		1885	1882
1890-1899		1898	1893, 1899^{+1}	1892, 1898
1900-1909	1901, 1909		1907	1908
1910-1919	1915	1914	1911, 1915$^{\#}$, 1918	1910, 1912, 1914
1920-1929	1920, 1922	1928	1920$^{\#}$, 1922$^{\#}$, 1926	1926, 1928
1930-1939		1937	1930, 1938^{+1}	1930, 1932, 1935, 1936, 1939
1940-1949	1941, 1946	1949	1942^{+1}, 1946*	1946
1950-1959			1953, 1956	1951, 1958, 1959
1960-1969	1969		1966	1960,
1970-1979	1973		1973$^{\#}$, 1974^{+1}	1971
1980-1989	1983, 1988	1980	1984^{+1}	1985
1990-1999	1995, 1998			
2000-2005	2003	2000		

Table 6.3 Comparison of low rainfall years from the Hobart/Eastern Tiers stations combined annual rainfall data and widespread fire years. Grey shaded years in bold (*) correlate to event years derived from a cross-dated East Coast *Phyllocladus aspleniifolius* chronology (Allen 1998), # = < -.75 sd. +1 = within 1 year of either sd class. n/d = no data.

6.4 Discussion

The temporal flow of fire scar data was presented in ways which showed it to be amenable to patterns which indicated distinct groupings of mean decadal frequency throughout the 274 year period. This is an important observation because it positively reinforces the analyses from earlier chapters which have sought to identify, qualify and mitigate potential sources of error in the fire scar data.

There were 25 years where fire scars occurred in the same year over 3 or more of the sites. Of these, 28% could be calibrated to years of low rainfall and/or narrow signal years from a cross-dated *Phyllocladus aspleniifolius* chronology in Eastern Tasmania. The biannual nature of wide followed by narrow ring width patterns in the *P. aspleniifolius* chronology has largely determined the event years listed in Table 6.3. Taken in isolation these event years can be misleading as there is no explanation for a pattern which occurs only in some trees and only for partial sequences within those trees demonstrating this pattern (pers comm. Kathy Allen, 15 June 2008).

The relationship between widespread fire years and 'dry' years indicates that dry conditions brought about by low rainfall can partially contribute to widespread fires. However, ignitions are not accounted for in this analysis as a much higher number, 18 of the 25 years (72%), were not calibrated with years of low mean annual rainfall, although the six additional years, which matched to within one year in either sd class, reduces this figure to 48%.

Potential explanations for the temporal and spatial patterns established in this chapter are further explored in the next chapter.

Chapter 7

Eras and explanations for spatial and temporal patterns

7.1 Introduction

Patterns of fire frequency derived from fire scar chronologies have variously been explained and interpreted by reference to the activities of people and/or climate. For example, Banks (1982, 1990b) found that distinctly different periods of fire frequency were related to documented changes in land use. Similarly, Burrows *et al.* (1995) observed breaks in fire frequency which were closely correlated to changes in cultural land practices (between the early 1840s and the mid 1990s). An increase in the frequency of injurious fire scars around 1850 was reported in all three studies and was interpreted to respectively represent: arrival of settlers and gold seekers deliberately setting fires for improved access and substrate examination; settler occupation and burning of surrounding land to provide feed for cattle; and, an increase in fire intensity resulting from a preceding period of fire exclusion.

Many examples of fire frequency patterns which are correlated with human activity are found in a wide range of fire histories from North America (e.g. Stokes & Dietrich 1980; Swetnam & Baisan 1996) and Europe (e.g. Conderra & Tinner 2000; Groven & Niklasson 2005). In particular, Weisberg & Swanson (2002) used the occurrence of fire scars derived from ring counts (compiled from ten separate studies) and found that there was a highly significant relationship between widespread fires and spatial patterns of fire frequency which were related to human activity.

There is still debate and conflict regarding the influence of Aboriginal fire (Horton 1982; Bowman & Brown 1986; Ryan *et al.* 1995; Benson & Redpath 1997; Bowman 1998, Abbott 2003). The absence of fire scars has been taken by some to infer low intensity fires. However, caution is needed in making this inference (Horton 1982; Gill & Catling 2002).

Data for vegetation fires ignited by lightning show that 222 incidents were attended for the entire State between 1998 and 2007 (Tasmania Fire Service unpublished data). Of these 44% were in eastern Tasmania and 25%, or an average of 6 incidents per year, were confined to an area between the northeast coast and the Derwent River. This could reflect bias in the data related to the locations of fire stations. There are no data for lightning ignitions prior to 1998.

The temporal and spatial patterns observed in the previous chapter warrant some explanation. The main aim of this chapter is to interpret the distinctly different changes in fire frequency identified in the 274 year composite chronology. The overarching question to which the entire thesis has devoted itself, *Have fire regimes changed in the Eastern Tiers of Tasmania?* is thus addressed. This chapter also investigates differences in land use between public (Forestry) and private sites as an attempt to account for spatial patterns.

The term: fire scar data, used throughout this chapter, refers to the adjusted, mean decadal fire scar data presented in Table 6.2 in the previous chapter.

7.2 *Data analysis*

7.2.1 Land tenure

Land use can have a significant impact on fire occurrence (Banks 1982, 1988, 1990a). The fire scar data were highly skewed towards more fire scars in the later part of the chronology but were not transformed. Instead, simple parametric (Student's t) and non-parametric (Mann-Whitney rank sum) analyses were applied to test for differences in between-site fire scar distribution (Zar 1999).

Analyses were done in three stages. First, an overall test using fire scar data from each decade 1740 - 2004 between the public land sites and private land sites was calculated. Second, the same data were tested in the same way but were clustered into distinctly different periods. Thirdly, the 27 decades of fire scar data were divided into four groups and visually checked for similarities and differences in temporal fire scar distribution. These groups were:

- Class 1 - public land;
- Class 2 - private land;
- Class 3 - forested (those sites at higher elevation in the north of the study area); and
- Class 4 - southern Midlands.

7.2.1.1 Variability in fire scar distribution

The ecological effects of variability in the fire regime are related to the capacity of organisms with vastly different life history traits to co-exist in dry forest systems (e.g. Burrows & Friend 1998; Walshe & Williams 2003). This is an important point. Theoretical approaches to modelling the concept of fire regime variability were evaluated by McCarthy (2003). He concluded that a major limitation to the application of available models in Australia was the relatively short time period of available data and long fire intervals. He advocated the continued use of averages, and variance about the mean to explore spatial and temporal fire regime variability. Because one of the striking features of the fire scar data is the distinctly different periods, characterisation of the within-period variability could be useful as a between-period comparison. There are two periods each of 80 years, one of 60 years, one of 30 years and one of 14 years. The standard deviation was used to illustrate variability in distribution of decadal fire scar years within and between each period.

7.2.2 A cross-disciplinary approach

A wide literature search was made to discover the reasons for the patterns of distinctly different periods in the mean decadal fire scar data. Sources from a range of disciplines were exploited.

7.3 *Results*

7.3.1 Differences in land tenure

The fire scar data covering 27 decades were grouped into classes 1 and 2 (Table 7.1). The publicly owned forested sites were never cleared, had been selectively logged and intermittently grazed prior to the 1970s. This group includes SW59C which is located in the eastern section of the southern Midlands, even though the grazing lease was not revoked until the 1990s. The privately owned southern Midlands sites, and two in the northern parts of the study area (Q and W) were cleared, partially cleared, intensively grazed and/or had been extensively logged. This arrangement constituted the division between public and private sites (Table 7.1).

The forested and southern Midlands sites, classes 3 and 4, are slightly different in composition and are representative of a geographic (northern/southern) split in the data.

Class 1		Class 2		Class 3		Class 4	
Public sites	Length of fire scar record (yrs)	Private sites	Length of fire scar record (yrs)	Forested sites	Length of fire scar record (yrs)	Southern Midlands sites	Length of fire scar record (yrs)
SH65A	1715 - 2002	W	1702 - 1994	SH65A	1715 - 2002	AR	1756 - 2004
SH12D	1752 - 2002	Q	1707 - 1982	SH12D	1752 - 2002	SHE	1772 - 2004
TO55H	1432 - 2002	AR	1756 - 2004	TO55H	1432 - 2002	LSP	1722 - 1977
TO52B	1750 - 2002	SHE	1772 - 2004	TO52B	1750 - 2002	SHU	1699 - 1970
MC21D	1767 - 2002	LSP	1722 - 1977	MC21D	1767 - 2002	FH	1864 - 1998
SW59C	1776 - 2003	SHU	1699 - 1970	W	1702 - 1994	SW59C	1776 - 2003
		FH	1864 - 1998	Q	1707 - 1982		

Table 7.1 Sites in the four land use classes with length of record based on the estimated age (± 7 yrs) of the oldest tree from each site.

Only two sites, with two trees each, in the southern Midlands (class 4) were recording fires from the 1740s: SHU and LSP. The spike in fire scars from this class in the early part of the chronology is evident in Fig 7.1. However, this is an artefact of the sample size conversion procedure. The adjusted data are positively influenced by the low sample numbers during these decades. Tenure otherwise affected the number of fire scars mainly during the 3rd European period between 1910 and 1950 by a notable departure between private land, mainly in the southern midlands, and public, mainly forested land at higher elevations in the north of the study area.

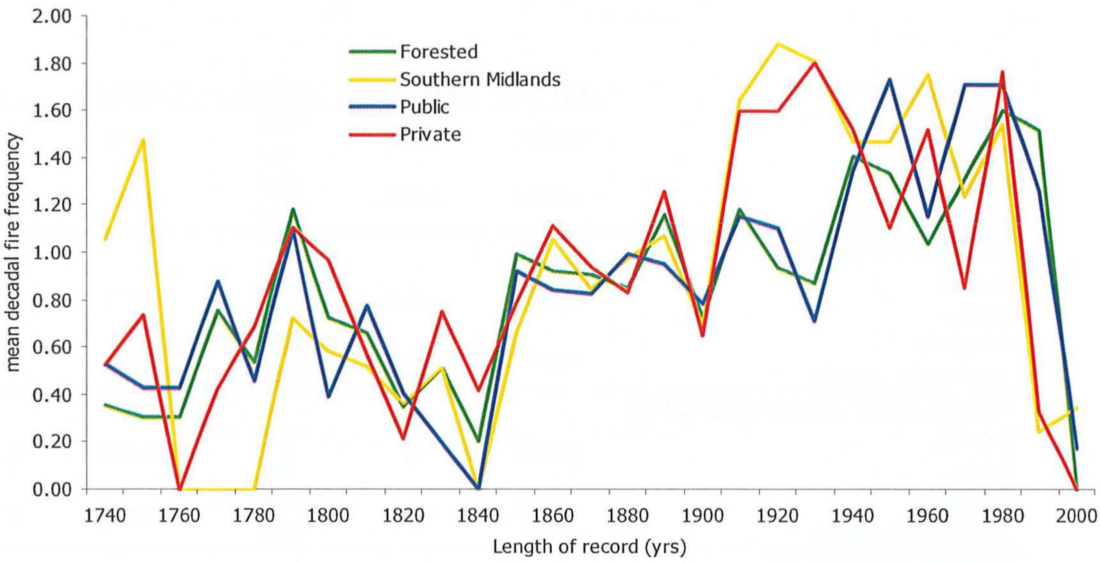


Fig. 7.1. The four classes showing fire scar distribution between 1740 and 2004.

There was no statistically significant difference (MW – P, Table 7.2) between the public land and private land when tested over the entire 27 decades (Table 7.2). However, as depicted in Fig 7.1, there was a marked departure in the pattern of fire scar distribution between forested and southern Midlands sites in the 3rd European period. This was significantly different (t test p = 0.003). However, the distribution between private and public land classes was not significantly different (t test p = 0.414) (Table 7.2) despite Fig 7.1 showing analogous patterns for both groups of similar classes. From the statistics, this indicates a spatial difference in the study area that is not related to land tenure. However, Fig 7.1 shows that it is for part of this period, between about 1910 – 1950 where the main difference lies. Location and tenure both contributed to this divergence. Later in the 3rd European period, about 1945 – 1985, the number of fire scars between public and private sites varies widely.

All periods (27)	MW - P	MW - W	Median	T statistic	P	DF
Private Public	0.8085	725	0.84 0.83	-0.33	0.739	51
Forested Southern Midlands	0.7752	725.5	0.87 0.85	-0.36	0.722	46
Aboriginal Period (8)						
Private Public	0.7905	65.0	0.50 0.65	-0.05	0.962	13
Forested Southern Midlands	0.6731	72.5	0.06 0.55	0.25	0.811	10
Transitional (1st European) Period (3)						
Private Public	0.3687	8	0.2 0.4	-0.134	0.274	3
Forested Southern Midlands	1.000	10.5	0.35 0.37	0.35	0.746	3
2nd European Period (6)						
Private Public	0.9333	38	0.85 0.85	-0.49	0.639	6
Forested Southern Midlands	0.8102	41	0.92 0.92	0.41	0.693	9
3rd European Period (8)						
Private Public	0.4566	60.5	1.20 1.55	-0.84	0.414	13
Forested Southern Midlands	0.0101	43	1.17 1.65	-3.60	0.003	13
4th European Period (1.5)						
Private Public	0.6985	6	0.66 0.15	0.94	0.511	1
Forested Southern Midlands	1.000	5	0.76 0.30	0.060	0.654	1

Table 7.2. Combined Mann-Whitney (Zar 1999) and student's t showing no significant difference between public and private sites when the fire scar data were tested over the entire length of the chronology. When grouped into periods, the 3rd European period showed a distinctly different trend between forested and southern Midlands sites. ( ) = n decades. MW-P = Mann-Whitney p statistic, MW-W = Mann-Whitney w statistic.

7.3.2 Periods and their characteristics

Five distinctly different periods were defined from the adjusted fire scar data (chapter 6). Here they have been labelled for reference and ease of identification. This labelling provides a foundation for exploration later in this chapter. The dates which determine each period are necessarily loose and reflect the effects of decadal delineation, rounding to a '10' at the beginning and end of each period.

Aboriginal Period 1740 – 1820. This earliest period of 8 decades is characterised by an injurious fire in the study area about once every 14 years. There are a minimum of two sites each with a minimum of two trees recording fires in the earliest decade. This period is characterised by a greater between-decade fire frequency variability than other periods (Table 7.4) despite lower sample numbers.

Transitional Period (1st European) 1820 – 1850. The second period of 3 decades is characterised by an injurious fire in the study area about once every 25 years. There was a very significant drop in fire scars at ~1820. Two sites did not record a fire scar throughout the entire period.

2nd European Period 1850 – 1910. Fire scar occurrence increased to about one injurious fire every 10 years in the third period of 6 decades. All sites except one (SH12D) recorded a large increase in fire scars in the early 1850s.

3rd European Period 1910 – 1990. There was a moderate hiatus in fire scar frequency for a few years between the previous period and this one. This period is characterised by about one fire every seven years and has the full complement of 104 trees recording for the first 5 decades. One site (SW59C) recorded two fires each decade between 1910 – 1990 and another (SHU) recorded two fires each decade between 1920 - 1960. Both of these sites had a long history of intensive sheep grazing until 1999 and 1984 respectively. SW59C is still unofficially grazed.

4th European Period (Current) 1990 – 2004. Covering 14 years, this period is characterised by a return to a fire frequency the same as that recorded for the Aboriginal period with a fire about every 14 years in the study area. There was a low number of decades (1.4) for this period.

7.3.2.1 Variability in the distribution of fire scars

The mean decadal fire frequency data from Table 6.2 are summarised in Table 7.3. Standard deviation and variance (Anderson-Darling normality test) showed that the variability of mean decadal fire frequency within each era was higher for the Aboriginal period (Table 7.4). The 4th European period was not tested due to paucity of data length (1.4 decades).

	Aboriginal Era	1st European Era	2nd European Era	3rd European Era	4th European Era
Decades	**1740-1820**	**1820 - 1850**	**1850 - 1910**	**1910 - 1990**	**1990 - 2004**
1	0.8	0.2	0.8	1.7	0.1
2	0.6	0.5	1.2	1.4	1
3	1	0.4	1	1.3	
4	0.6		0.9	1.5	
5	0.9		1	1.6	
6	0.3		0.9	1.4	
7	0.7			1.5	
8	0.7			1.5	
Mean period frequency	**0.7**	**0.4**	**1**	**1.5**	**0.7**
Average years between fires	14	25	10	7	14

Table 7.3. Mean decadal fire frequency summarised from Table 6.2.

	Aboriginal Era	1st European Era	2nd European Era	3rd European Era	4th European Era
Decades	**1740-1820**	**1820 - 1850**	**1850 - 1910**	**1910 - 1990**	**1990 - present**
St.dev	0.17525	0.15275	0.13292	0.0991	*
Variance	0.03071	0.02333	0.01761	0.0098	*

Table 7.4 Descriptive results showing more decadal fire scar variance in the Aboriginal era than in the other three eras .* = insufficient data.

7.4 Discussion

Fire years through most sites followed a very similar distribution from the earliest year of the chronology (1740) until about the 1910s. A divergence between public and private land in the pattern of distribution was evident between the 1910s and ~1950 and continued, albeit less markedly, until around 1990. This contrasts with other fire history reconstructions where great between-site variability in temporal fire scar distribution has been recorded (e.g. Banks 1982).

7.4.1 Explanations for distinctly different periods

7.4.1.1 1740 - 1820

Aboriginal period ***1740- 1820***

Tasmania was officially settled by Europeans in 1803, although coastal areas of the island had intermittently been visited (and documented) by sea-based explorers since 1642 (Robson 1983; Thomas 1994). Aborigines, comprising family groups and larger tribal associations, occupied the island.

Strong cases have been made for the use of fire in forests by Aborigines. Based on differences in sediment cores covering the same time frame between Tasmania and New Zealand, one researcher suggested that Aborigines have been burning the vegetation in Tasmania for > 70,000 years (Jackson 1999b) and that the eastern forests as had been "*...severely modified by extensive and constant firing*" (Jackson 1999a:13). Gammage (2002, 2005, 2006) contends that the Tasmanian Aborigines deliberately and predictably burned landscapes to provide a continuous supply of food and other resources, effectively cycling the vegetation to produce edges which were preferentially used by prey animals. Others have found no explanation other than fire for the boundaries between rainforest and grassland which are evident in many places in Tasmania. In northeastern Tasmania, Ellis (1984, 1985), Thomas (1991, 1993) and Ellis & Thomas (1998) worked extensively with soil properties and pollen respectively to explain such boundaries, naming Aboriginal fire as the causal agent. Similarly, in the southwest, Marsden-Smedley (1998) argued that the vast plains of buttongrass which abut eucalypt and rain forest were an artefact of Aboriginal burning. A case was made for a return to Aboriginal-style burning for the maintenance and ecological health of buttongrass (*Gymnoschoenus sphaerocephalus*) plains and protection of adjoining non-buttongrass communities (Marsden-Smedley & Kirkpatrick 2000).

In southeastern Australia generally, there is an abundance of evidence that Aborigines used forests as "*...an important foci for Aboriginal resource exploitation and ritual*" (Cosgrove 1982:2). Boutland (1988) and Feary (1988) compiled extensive review documents detailing the use of forests and woodlands by Aborigines in southeastern Australia. Excerpts from explorers journals were blended with evidence from archaeological, paleoecological, palynological and contemporary ecological research to irrefutably place Aborigines using fire in forests and woodlands. After exploring the available evidence for Australia-wide Aboriginal burning in an epic treatise, Bowman (1998) concluded "*It is wrongheaded to ignore the ecological impact of a long history of Aboriginal burning*" (Bowman 1998:405).

More specifically, Cosgrove (1982) and Lourandos (1970) found archaeological evidence for extensive Aboriginal forest use in the study area. Quarries, stone tools and artefact scatters were found beside creeks, river flats, drainage depressions and benched areas at a range of altitudes in the topographically diverse landscapes of the Eastern Tiers. After 1970, forestry burns made visible this type of evidence but roading and harvesting had obliterated many other sites, because flat areas were preferentially used by both Aborigines and loggers.

Others (e.g. Clark 1983a; Benson & Redpath 1997; Kershaw *et al.* 2002) prefer climate as the driving force behind the evolution and distribution of Australian vegetation and believe that > 30,000 years of Aboriginal occupation had little or no impact. One writer succinctly encapsulates these views: "*Aboriginal use of fire had little impact on the environment and ... the patterns of distribution of plants and animals which obtained 200 years ago would have been essentially the same whether or not Aborigines had previously been living here*" (Horton 1982: 237).

There is likely to be a perennial debate regarding the use of forests by Aborigines and their impacts (e.g. Bowman 1998; Feary 2005). Because the frequency of fire in the forests and woodlands of eastern Tasmania, before European influence (i.e. before the mid 1600s when disease may first have been introduced), may never be known, it is important to establish the integrity of the fire scar record of the Aboriginal period, because European use of the forests and woodlands has since altered the distribution, structure and composition of vegetation (Kirkpatrick 1994; Duncan & Brown 1995) making comparison between subsequent eras complex.

Was the Aboriginal fire regime intact until the first break in the fire scar data?

There are many historic references to Aboriginal fires intended for deterrence (e.g. Meredith 1979: 77-88; Roth 1899; King 1963; Robson 1983; Kee 1990; Brown 1991; Pyne 1995:34). Moreover, after > 30,000 years of occupation (Jones 1969; Singh *et al.* 1991; Cosgrove 1989; Cosgrove *et al.* 1990; Thomas 1991; Ellis & Thomas 1998; Jackson 1999b) one would expect a sound predictive knowledge of fire use by Tasmanian Aborigines (e.g. Gammage 2006). Thomas (1994) distilled the ethnohistorical record and made a strong case for the tactical use of fire by Aboriginal people confronted by Europeans in coastal areas. However, Europeans were not used to seeing fires in their country-of-origin landscapes and, through ignorance, their interpretation could have grossly exaggerated the nature, extent and size of fires they saw (Watson 1969; Thomas 1994). The important point is that fires lit for defensive, offensive or tactical purposes could have influenced the fire scar evidence for a 'natural' regime by increasing the number and distribution of fire scars, thus introducing an artifice into the dataset prior to 1803. However, reports of Aborigines lighting strategic fires before the 1820s are from coastal areas and from inland areas in the late 1810s (Thomas 1994). Evidence for tactical fires used by Aborigines in other areas includes northern Australia (Preece 2002) and the American southwest when archival documents dating to the seventeenth century were analysed (Kaib 1998 cited in Swetnam & Basian 1995).

Supporting evidence for the persistence of a 'natural' Aboriginal fire regime until ~1820 comes from the Sydney area (Cumberland Plain) where, in the 1820s, the Aborigines were observed to be still burning eucalypt woodland understorey in the traditional manner despite the area having been explored and eventually settled around this time (Kohen 1986). Pre-settlement burning practices by Aborigines in inland (Swan coastal plain) south-west Western Australia was also thought to have persisted for some time after settlement (Hassell & Dodson 2003: 81).

The decrease in fire scars in the 1820s which delineates this period from the next, is co-incident with the build-up to, and onset of, the Black war 1824 – 1830. By the 1830s few Aborigines survived in the wild in Tasmania (Meredith 1979: 77-88; Robson 1983; Plomley 1992). Indeed, during the 1820s Aborigines were hunted and their fires would have betrayed their locations. Tasmania, without an external source of warmth, is a cold environment for human beings (pers. obs.).! Plomley (1992) analysed accounts of items stolen by Aborigines during this period. Blankets and food were the most common items taken, the assumption being that warmth from them was a survival essential as the Aborigines most likely ceased, or at least severely curtailed, their use of fire (Pyne 1991:129). By 1835 most of those who remained of the Aboriginal population had been moved to Flinders Island. Thus, the Aboriginal fire regime is unlikely to have survived beyond ~1820.

7.4.1.2 1820 - 1850

Transition Period (1st European) ~1820 - 1850

A transitional period is likely to have been experienced by the forests in the period between the cessation of Aboriginal burning in the early 1820s and the active management of grazing land by European settlers.

Hunting for food and skins with packs of dogs appears to have impaired the development of agriculture throughout the 1820s and 1830s (Boyce 2006). This activity was not entirely in keeping with official plans for agriculture development and such independence was not encouraged. A dog tax in 1830 was subsequently introduced as a means of control, whereupon dogs were abandoned. With growing numbers of sheep, dogs were shot and poisoned throughout the 1840s and 1850s. It is unknown whether the labourers employed by the colonists preferred to hunt in burnt or unburnt forest.

There are accounts of settlers burning the bush "*...as the aborigines used to...*" (Meredith 1979: 45, who was writing in 1852). An understanding of fire use between Aboriginal and European could have been transferred but is likely to have occurred in the first decades of settlement. Boyce (2006) has documented very early settlers (1800s) sharing land, hunting and dogs with the Aborigines in the Hobart area. Their relatively isolated outposts provided early shepherds with opportunity for interaction with Aborigines (Cubit 1996) and it is thought that such opportunity for exchange may have resulted in the transfer and adaptation of fire technology from remote areas to lands becoming settled and increasingly stocked with sheep. If the shepherds had learned about fire from the Aborigines then this information would have eventually been passed on to the landholders, thus setting the scene for a practice which continued in some parts of the Midlands until the 2000s (Gilfedder *et al.* 2003).

The southern Midlands sites, except SW59C were alienated prior to 1820 and the two northerly sites (Q and W) were alienated in the 1820s. The remainder of the northern study sites were never alienated and there was little movement through the interior of the northern Eastern Tiers until around the 1830s. The southern Midlands sites recorded marginally more fires than those in the north during this period and may have been related to earlier settlement with concomitant clearing and grazing.

The demise of Aborigines and their burning practices would have impacted on the vegetation. Indeed, an early Government Servant, decrying the loss of Tasmanian Aborigines, stated: "*...the consequent absence of extensive periodical fires* (has allowed the bush to grow up) *to a most important degree, spoiling the sheep runs and open pasture and affording harbourage to snakes and other reptiles which are becoming yearly more numerous*" (Lieutenant Henry Bunbury cited in Pyne 1991: 129). Heathy and shrubby understorey vegetation would have gained volume during this period and, without fire, litter accumulation would have increased. In the early part of this period, fires were probably infrequently lit by landholders or their employees. When they did eventually start to use fire it was probably with varying degrees of predictive knowledge of fire behaviour due to inexperience (Pyne 1991: 129). When the forests did burn, it is possible that they did so with higher intensity due to increased fuel (King 1963; Duncan 1981). Sheep numbers were steadily increasing (Kirkpatrick 2007a).

Sheep runs (hilly, often steep bush country) would have been becoming established during this period, radiating east and west from the Midlands valley. These areas would have been periodically burnt by shepherds for the provision of fresh feed. Conditions, such as property improvements achieved by clearing and burning, were placed on the holders of some land grants (Robson 1983). It is doubtful that such conditions were widely met immediately upon receipt of a land grant because many landholders elected to remain in the relative safety of Hobart leaving shepherds or leaseholders in charge of their properties (Scott 1965) as bands of escaped convicts roamed at large.

An alternate view of the events during this period is one of more burning, more regularly and more thoroughly thereby eventually ensuring fires of low intensity, due to a scarcity of fuel, which were less likely to cause scarring about the stems of eucalypts. As Kirkpatrick (2007a) pointed out, landholders had access to convict labour and were many more in number than the entire Aboriginal nation in earlier times. The flaw with this view is that the Eastern Tiers were in their infancy of settler influence, limiting opportunity to maintain annual fire regimes. Only two sites (W and AR) recorded fire scars in two successive decades during this period. Site AR was part of the Font Hill (1805) grant and a grazing regime would have been well established. W is favourably situated on a gently undulating plain on the western slopes of the Eastern Tiers and was granted in the 1820s.

An overland route from Hobart to the East Coast was first explored in 1821 (Commonwealth Parliament 1921) and it wasn't until the mid 1820s that small landholdings were granted on the central East Coast around Swansea just east of the southern part of the study area. All the best, most productive land close to Hobart in the Midlands valley had been alienated before 1825 (Roberts 1924), leaving the more distant hilly to mountainous Tiers country to the east ripe for alienation during this period. Indeed, much of the central Midlands and the central East Coast was alienated between 1823 and 1844 (Scott 1965). The forests of the northern part of the study area were never alienated but were subject to timber licenses from the 1830s. These were granted for eight week terms throughout this period. In the 1830s, records of timber licenses showed no reference to the lighting of fires but by 1845 clause 4, "*...the party holding this license is requested not to fire the bush*" was inserted (Archives Office of Tasmania LSD 1/64). In addition, seize and sell operations were apparently rife in parts of the Eastern Tiers. Landholder complaints to the crown of unauthorised fires and pailings theft throughout the 1840s (Archives Office of Tasmania 67/14789) indicating increasing human activity in the forests and reflecting the high value placed on timber protection. The activity of people in the forests was about to substantially increase.

7.4.1.3 1850 - 1910

Second European period **1850 - 1910**

A complex of factors could have influenced fire activity during this period. However, the implications of one factor were immediate. The finding of gold in Victoria in 1851 saw a mass migration of settlers, farm workers, shepherds and even whalers from Tasmania to the goldfields (Robson 1983). Indeed, 23% of the male population emigrated from Tasmania between 1851 and 1853 (Barnard 1854). An abrupt labour shortage may have meant that the capacity to either deliberately initiate or control burns on run country was temporarily impaired. Meredith (1979: 45) describes deliberately lit fires in the vicinity of her property on the central east coast in the late 1840s which were not controlled and were not extinguished until it rained.

In other parts of the Eastern Tiers, any regular burning up until this time may have temporarily ceased causing the accumulation of both live and dead fuel, or may not have been widespread in the first place. The steady build-up of dead and scrubby fuels during the previous period would facilitate fires of high intensity in conducive conditions. The increased tree scarring during the 1850s could be the result of this type of fire producing tree injury rather than increased fire frequency.

Another contributing factor for the large increase in fire scars during the early 1850s could have been attributed to those who did not migrate but instead chose to remain in the forests engaged in legitimate, or otherwise, timber getting. There was a drastically drained male labour population with 6613 departures from Tasmania in 1851. This rose to 21,917 departures in 1853, but was partially offset by strong immigration and huge increases in the value of trade, especially timber (Barnard 1854). While quantities of goods did not necessarily increase, the early 1850s appeared to be a boom time for Tasmania with the value of imports rising 354% to £2,273,397 and exports 263% to £1,756,316 between 1851 and 1853 (Barnard 1854). The demand for Tasmanian timber rose sharply during the early 1850s primarily to feed the goldfields infrastructure in Victoria. Some of the gold-rush wealth was fed back into Tasmania because the value and quantity of exported timber rose 1500% from 1851 to 1853, making this industry more profitable and reliable than the goldfields. In order to get the timber, fires were used to clear the understorey vegetation to enable access and reduce the risk of unplanned fire in the immediate vicinity. Despite this, or because of it, accidental fires from such a high increase in timber-getting activity, perhaps some of it undertaken by inexperienced bush people eager to capitalise on this valuable resource, could have occurred during this phase. Forest fires rapidly became problematic. The first Bush Fires Act in Tasmania was introduced in 1854 describing penalties for the lighting of summer fires but was apparently largely ignored (Wettenhall 1975).

The fires probably continued as an unprecedented amount of Crown Land was sold in 1852 and 1853 (Barnard 1854). Those returning rich from the goldfields bought land and their clearing and burning activities would have added to the timber getting fires.

The nature of vegetation and therefore fuels were also probably changing due to the vast herds of sheep. The impact of grazing by sheep reduces the grassy fuels. What remained of the native macropod (*Macropus* spp. and *M. giganteus*) population (West 1852) would have been preferentially browsing herbs and shrubs but with probable negligible effect due to excessive hunting in the transitional period, 1820 – 1850. With 1.9 million sheep in 1853, grass would have been at a premium (Barnard 1854). Co-incident with a gold-rush induced labour shortage, timber extraction becaming as lucrative as gold fossicking, grassy fuels were decreased by grazing while shrubby fuels accumulated due to low numbers of marsupial browsers. The abrupt increase in tree scarring in the early 1850s could partly be the result of changed fuel structure which led to increased flammability and continuity and therefore higher intensity fires.

Perhaps attempts were made to confine and protect increasingly large numbers of sheep from theft and predation after the first wave of labour loss in 1852 (Morgan 1992; Kirkpatrick 2007a). Timber post and rail fencing was a major forest product by the 1850s and fencing most likely became a priority. As a result, protection from fire was a major consideration and was largely undertaken by the maintenance of reduced fuel about fence lines using fire (Meredith 1979: 45).

During the middle of this period, Tasmania was the leading producer of trams and tramways for the timber industry. Tramways were extensively used in Tasmanian forests - first in the southern forests and spreading to other areas of the state much later. Saw mill operators had complete control of forests - Tasmania was the last State to develop a Forest Act in the 1920s - throughout this entire period and preferentially took only the best trees (Evans 2005). The retention of timber on selected land was illegal and in those areas remote from roads or ports, entire stands were ring-barked and burnt (Stubbs 1998). It is not clear when ring-barking commenced in Tasmania (Evans 2005) although Pyne (1991) reported the activity from the 1840s in the Midlands. This method involves the killing of standing trees by removing a collar of bark around the stem. The dead trees were then repeatedly burnt in order to remove them, and accumulated debris, in preparation for pasture development or to improve rough grazing capacity. Each repeated fire in forested areas of sufficient intensity could have encouraged new growth and seedling germination requiring more fire for its control. Grassy fuels would have been generally low due to the ubiquitous sheep grazing. A cycle of burning in response to vegetation growth could also perhaps explain the increasing occurrence of fire scars throughout this period which, after a short hiatus, grew to almost double in frequency during the next period.

A well documented drought in the early years of the 20th C (Marsden-Smedley 1998) may have been related to an increase in the number of fires in the late 1890s, especially in the southern Midlands sites. There was a sharp drop in the number of fire scars in the few years prior to 1910 perhaps reflecting a public response to an unpleasant association with drought and fire, assuming human ignition. If so, this association did not remain strong in the collective mind because by the mid 1910s, the fire frequency had increased to significantly higher levels than at any time in the previous two periods.

After the rash of fires in the late 1890s there is a marginal drop in the numbers of fires for the first decade of the 20th century, more pronounced in the southern Midlands than in the forested parts of the study area. Possibly the area had been well cleared and burned by this time after a peak of fire activity through the 1890s, resulting in low intensity fires. A boom, resulting from Federation in 1901 which made 3rd class land, most of it in the Eastern Tiers, readily available via relaxed purchase terms, occurred in the period 1902 – 1911 (Scott 1965). The 'closer settlement' scheme became a reality through the Closer Settlement Act 1906. This act was designed to make more land available to more people for the sole purpose of farming. Title was not provided until such 'improvements' were carried out. (An Act of Parliament waived the clearing before title clause only in 1976).

The entire range of circumstances described here most likely contributed to the higher than previous levels of fire scar incidence. As the colony prospered into the 20th Century, lighting fires became an integral part of life for people in the bush.

7.4.1.4 1910 - 1990

Third European period **1910 - 1990**

The effects of more people moving onto land previously unavailable resulted in fires lit for land clearance of which escapes were also probably commonplace. The

Closer Settlement Act of 1906 enabled the breakup of some of the larger landholdings placing more people on to smaller lots (pers. comm. Tim Jetson). Property 'improvement' requirements (ringbarking, clearing, burning, fencing, buildings, pasture development) were still imposed. Indeed, there are surveyors records which comment: "*only improvement is the burning*" (National Archives of Australia #719) – this, for a Midlands property at an unknown date prior to 1929. A levelling off in fire scar evidence occurred across all sites, both public and private, from the mid 1910s until about the mid 1920s. This fits with the period during which much of the land granted under the closer settlement scheme of the first decade of the 1900s reverted to the Crown during and, for a while after, World War I (Scott 1965).

The mean frequency of fire scars increased from about one every ten years to one every seven years across the study area between these periods. It appears that a culture of burning had developed during the preceding 60 years, almost a single generation, and fires had become an entrenched tradition which was passed on. Fire was so prevalent that attitudes to it were quite relaxed, reflecting familiarity with its use (see Gilfedder *et al.* 2003; Kirkpatrick *et al.* 2007b). Increasingly, industrialisation of activities that were previously performed by horses or bullocks opened up a wider range of options for land exploitation and transport in particular. Pyne (1991, 2006) has concluded that Australians on the land developed a penchant for fire during this period and generally became very comfortable with its use. For example, the mail service from Swansea, on the East Coast to Campbell Town, in the northern Midlands in the 1920s and 1930s was operated by vehicles which ran gas producers. These devices were fed with organic material which made methane gas to power the vehicle. The ash was tipped out on the side of the road en route and restocked, often with cow dung collected from roadside paddocks. Many of these vehicles operated in Tasmania during this time and were directly responsible for fires (Gilfedder *et al.* 2003: 32).

'Bad' fire years occurred throughout Tasmania in 1913-1915, 1927, 1931/32, 1934, 1939, 1945/46 and 1961 (Wettenhall 1975; Luke & McArthur 1978; Pyne 1991). 'Bad' fire years would also have occurred in previous periods (such as in

1851 and 1898/99) but were either not recorded with the diligence of those record-keepers in the 20th Century or fire was less remarkable and therefore not recorded. Even after the horrendous widespread fires in Victoria, NSW and the ACT of 1939 (Collins 2006) the incidence of fire scars did not decrease on the private land in the study area. There was a marginal decrease for several years in the late 1930s in the forested public land sites but this appears to have occurred before the 1939 fires. The effect of the Victorian fires of 1939 was to initiate reform in the system of forest management in Victoria and New South Wales (Stretton 1939). It appears that no such effect occurred in Tasmania (Collins 2006).

The more open and grassy, southern Midlands sites, which, in all likelihood were more intensively grazed than the forested sites, recorded significantly more fire scars between 1910 – 1990 (Fig. 7.1). It seems most likely that landholders were regularly burning their runs for fresh pick.

Sheep numbers were still high until the 1960s when wool prices fell and, according to one source from the Midlands *"Burning was conducted relative to grazing demand"* (Gilfedder *et al.* 2003: 26). Fire was widely and, by this time, traditionally, used in run country in the southern Midlands and the Eastern Tiers up until the ~1970s. It wasn't until the fires in the south-east of 1967, and the following parliamentary enquiry (Chambers and Brettingham-Moore 1967), that adequate resources were allocated to undertake broad scale fuel reduction burning and fire suppression was actively promoted. Commercial forestry operations commenced in the Eastern Tiers in 1971. The debris from logging (slash) was initially burned hot to stimulate regeneration from aerially sown seed (Dickinson & Kirkpatrick 1985) then later, cool, slash reducing burns were introduced. There were escapes but these were poorly recorded and very poorly mapped. Forestry operations became more widespread and efficient at timber extraction. Sheep were considered an anathema to regenerating eucalypt forests and grazing leases on public land were cancelled through the 1970s and 1980s. However, a grazing lease was maintained on one publicly-owned site (SW59C) until 1999. This site recorded the most fire scars per tree and overall. The single fire in the 2000s was recorded from this site.

It would appear that, unlike the southwestern United States (e.g. Touchan *et al.* 1993; Grissino-Mayer 1995), the presence of large numbers of sheep in Tasmania was co-incident with increased fire scars. This indicates that humans were the source of ignition because native pasture and native runs were regularly burnt to promote fresh growth for sheep feed. If ignitions from lightning have remained constant throughout the past ~300 years, then climate cannot explain the fire frequency changes reported here.

7.4.1.5 1990 - 2004

Fourth European period - current ***1990 – 2004***

There are several factors which have influenced the lack of fire scar evidence during this period. Commercial eucalypt plantations were established throughout Tasmania in the 1960s and 1970s. Harvesting of the fast growing *E. nitens* and *E. globulus* plantations were underway in the early 1990s relieving some of the pressure on the native forest estate for a short period in the early 1990s. The enactment of the Tasmanian Regional Forest Agreement in 1998 (AFFA 1998) enabled a renewed assault on the forests but, with the advent of the Forest Practices Board and subsequent Forestry Code of Practice, new guidelines and constraints were placed upon the use of fire for regeneration of forests after logging (FPA 2003).

Wildfire is detrimental to production forestry because the presence of charcoal is inconsistent with the needs of Japanese woodchip buyers who demand, and pay for, a clean product. Wildfire can kill regenerating eucalypts thereby severely affecting a future return. The public forests are in various states of regeneration. The forests are managed to produce trees which constitute high volumes of fuel in solid stands of varying ages and heights. Both vertical and horizontal fuels, more notably in the older regeneration areas, could be described as continuous (pers. obs.). In addition, the vocal public and political perception of escaped forestry burns laying waste to the forests of the 1980s demanded changes (Watson 1990; Gee 2001). Slash burns after logging activities are today conducted with well trained crews of people and adhere to explicit guidelines governing conditions under which a fuel reduction fire may be started (FPA 2003). The vigorous, co-ordinated and better resourced suppression activity by land management agencies, Forestry Tasmania (FT) and Parks and Wildlife Service (PWS), and the emergency response agencies Tasmania Fire Service (TFS) and State Emergency Services (SES), has enabled a quicker and effective response to any escapes or other unplanned fires. In particular, it is the inter-agency agreement developed initially between FT and the TFS in 1992, which, a few years later, included the PWS that has enabled a unique approach to fire management in Tasmania. Whilst initially challenging, this system has been defined and strengthened by an actively cultivated environment of trust and respect developed from within the ranks, through inter-agency friendships over many years (A. Blanks pers. comm. 13 Jun 2008).

Therefore, during the current period, fires are generally efficiently extinguished. The contemporary source of ignition is via the arsonist or through an accidental escape. For example, TFS data show the strong relationship between settlement, demography and ignitions for Wellington Park, near Hobart (WPMT 2006). Ignitions are increasing in frequency as fire suppression agencies are increasing response capabilities.

A survey of many Midlands landholders (Gilfedder *et al.* 2005) revealed that few of them have purposefully burnt their run country since the 1970s, although Kirkpatrick *et al.* (2007a) reports the burning of sagg (*Lomandra longifolia*) and grasses in open situations on some properties up until the present day. Liability for escaped burns has been legislated into existence in the early 2000s creating an unacceptably high risk for landholders (e.g. Mokany *et al.* 2006:64). The explanation for the lower incidence of fire scars during this brief period is related to the combined influence of these factors.

7.5 Conclusion and Application

This thesis documents changes in fire frequency between 1740 and 2004 and interprets the causes of these changes. The sampled eucalypts are not amenable to cross-dating. The fire scar data was demonstrated as reliable through the interrogation of ring counts and a range of potential sources of error were shown not to have any substantial influence on the accuracy of the fire year chronology. Distinct patterns of frequency in the fire scar data were subsequently explained by the assembly of a multidisciplinary cultural overlay.

It is difficult to interpret the observed changes in fire frequency as being caused by climate because the differences in the distribution of fire years (periods) were consistently different throughout the length of the chronology. These differences do not relate to rainfall patterns (1855 – 2004) which otherwise could have been suggestive of a strong relationship between drought and increased incidence of fire scars. Within each of the three most recent periods there are years of both high and low rainfall (Fig 6.7). There is no consistent correlation between years of high or low rainfall and an increase or decrease in the distribution of fire scars. Furthermore:

a) there are no empirical data for rainfall or temperature prior to the mid 1850s and none for lightning prior to 1998 with which to link trends in fire frequency from the early part of the chronology;

b) the correlation between years of low annual rainfall between 1855 – 2004 and fire years was 28% suggesting a weak relationship between drought and fire but not helping in identification of an ignition source;
c) changes in climate, if driving lightning, would need to be abrupt and severe to account for the large decreases and increases in fire scars detected at particular points in the record, across most sites;
d) the cultural record is a vast and compelling body of evidence for anthropogenic fire in the Eastern Tiers and southern Midlands.

7.5.1. Variability in the fire regime

Between-decade variability was tested within four of the five periods using the mean decadal frequency data (section 7.3.2.1). The highest variance was observed in the Aboriginal period which covered 80 years (range 0.3 – 1 fire years/decade).

Variability in fire occurrence (frequency and patchiness) and intensity (ground or crown) in dry eucalypt forests is vital for the maintenance of diversity of forest structure and species composition and habitat. Over time, too frequent fires can favour resprouters over seeders (e.g. Fox & Fox 1987; Knox & Clark 2006) although other factors such as drought are important. Intense fires can be lethal resulting in even-aged stands. If the biota has evolved with thousands of years of Aboriginal ignition, and there is a great diversity of life history attributes within communities, then variability in the components of the fire regime must have collectively contributed to the forcing of such attributes. Some researchers have even suggested that dry forests in Tasmania have developed on anthroposols, the result of many thousands of years of Aboriginal burning (McIntosh *et al.* 2005).

The evolution of our understanding of the implications of the fire cycle, fire frequency and fire intervals on the landscape have most recently been reviewed by Gill (2003). In an effort to achieve a diversity of outcomes such as conservation, ecological systems maintenance, fuel reduction, forest resource extraction and forest management, various methods have been proposed to determine the likelihood of fire occurrence in a given landscape. In almost all cases the mean is used as a measure from which to interpret the historic or predicted future passage of fire. There has been focus on time-between-fires or the fire interval using data collected from fire scars (Burrows *et al.* 1995, Fulé *et al.* 2003, Reed & Johnson 2004) and from life history knowledge of component plant and animal species (e.g. Clark 1996; Tolhurst & Friend 2003). For example, the model developed by Bradstock *et al.* (2005) attempts to reconcile apparent contrasts in fire requirements for a mallee ecosystem, of which *Callitris verrucosa* is one component, and the mallee fowl (*Leipoa ocellata*), another. It includes parameters which relate to fire characteristics (including unplanned fires), landscape form, plant dynamics, habitat and life history attributes of mallee fowl and explores the consequences of particular prescribed fire frequency. Emphasis is placed on the need for the 'invisible mosaic' of the site fire history to be made visible because the spatial and temporal extent of each successive fire is critical for enabling quantification of the state of the prevailing fire regime which guides the decision making process (Bradstock *et al.* 2005). They concluded that a comprehensive landscape ecological approach was required.

Another example, which uses surrogates to determine an appropriately variable fire frequency, is based on information derived from forest age, area and hollow occurrence data in Victoria (McCarthy *et al.* 1999). The data were collected from Mountain Ash (*Eucalyptus regnans*) forests subjected to European land management over the past 200 years. Their results showed that using hollow numbers and occupancy alone, a mean high intensity fire interval of ~250 years would support a maximum '*...total abundance of mountain ash trees with hollows*' (McCarthy *et al.* 1999). This contrasted with age structure parameters where the mean fire interval was predicted at ~107 years. A constant mean fire interval in the model was needed to provide consistency between predictions based on the three parameters however their results were in accordance with previous work where a mean fire interval of ~100 years was postulated to describe the prevalence of multi-aged *E. regnans* forest. In reality, a constant fire interval is impossible and the authors suggested that biological factors contributing to vegetation and fuel changes may be more useful indicators to model.

The variability of fire frequency can be theoretically modelled according to the input parameters (life histories of component species, topography, weather conditions such as rainfall, fuel conditions, fire behaviour, time-since-last-fire etc.). However, contemporary human beings as a source of ignition cannot be adequately predicted because arson is prevalent among modern human beings. Dry forests are generally not managed sensitively because we do not rely on them for the most fundamental of survival requirements: food. Forests are widely managed as an economic commodity from which timber, wool and honey are produced or they are reactively burnt to reduce fuels for temporary population protection (viz. 10,000 ha fuel reduction burn near the East Coast town of Bicheno in September 2007, pers. com. B. Merritt October 2007). We are, today, simultaneously mindful of litigation should fires lit on land under one management regime escape on to land under another.

The fire scar data revealed very low between-decade variability in the 3rd European period between 1910 – 1990. It is not possible to determine variability of frequency in the 4th European period because 14 years is an inadequate timeframe. As lightning is an intermittent source of ignition in eastern Tasmania (Jackson & Bowman 1982; TFS unpubl. data p.186) the incidence of fire is most frequently determined by people. If relative climatic stability has been the norm throughout the Holocene (Dodson & Mooney 2002), indicating neither more nor less lightning, changes in fire frequency since European settlement cannot be adequately explained without accounting for people as a source of ignition (Carey & Banks 2000).

7.5.2. To the future

"*...at the intimate level of local processes and human action, the effects of people on vegetation are more clearly evident.*" Thomas (1993:9).

Sediment records covering thousands of years are generally interpreted to infer that climate plays a stronger role in the distribution and composition of vegetation (pollen) than fire (Clark 1983b; MacPhail 1979, 1980) because of the time scale involved (Thomas 1993). Palaeo-disciplines have provided evidence that fire regimes generally have changed after the occupation of Australia, first by Aborigines and later by Europeans (e.g. Singh *et al.* 1981; Dodson & Mooney 2002). Scale is relevant here as a problem with charcoal sediments analysed in palynology, palaeoecology and archaeology is the general coarseness of data resolution (Clark 1983a), due in part to the long time-frames over which each discipline covers. Other problems include: charcoal may breakdown into smaller segments and be continuously washed into deposition sites for many years after a fire thereby hindering interpretation (Blong & Gillespe 1978) and, rainfall after a fire can affect the degree to which charcoal is represented (or missing) from a sediment sequence (e.g. Green *et al.* 1988). These problems seem to have been challenged by work in southeastern NSW. Fine-resolution evidence for the occurrence of frequent fires during the period 1950 – 1975 was found in the charcoal record of a peat bog in Bega Swamp yet fire scars in adjacent eucalypts (*E. pauciflora*) were few, indicating occasional more intense fires (Green *et al.* 1988). The evidence for frequent low intensity fires found in the charcoal record which was not recorded in the adjacent eucalypts could, like the grasstree research (Ward *et al.* 2001; Ward 2006), provide supporting evidence for making visible the 'invisible mosaic' (Bradstock *et al.* 2005) of past fires, at least on the local level.

Perhaps a warming climate will bring extended fire seasons where the conditions for fire are generated on more days during each year. However, unless there is a concurrent increase in dry thunderstorm activity, each fire still requires a source of human ignition.

Brookhouse (2006) has suggested that eucalypts have potential for further dendrochronological examination. The cross-dating attempts reported in this thesis showed little value in this approach. Instead, with careful radius selection, this study has demonstrated that it is possible to date fire scars and age large, old eucalypts using ring counts. The potential for the development of fire histories in other areas, particularly those with forestry activity, is consequently greatly expanded using this method.

The fire scar data show that the temporal and spatial distribution of fire scars in Tasmania's Eastern Tiers has increased consistently since ~1850, and decreased since the early 1990s. It is now possible to ask questions regarding the implications of such knowledge. As many researchers have observed (e.g. Burrows *et al.* 1989; Bradstock *et al.* 1995; Bradstock *et al.* 1996; Burrows & Friend 1998; Gill & McCarthy 1998; Burrows *et al.* 1999; Friend *et al.* 1999; Gill 1999; Gill *et al.* 1999; Gill & Catling 2002; Bradstock *et al.* 2005; Knox & Morrison 2005 to name but a few), perhaps future questions regarding fire frequency should continue to relate to the requirements of groups of species and the maintenance of habitat with a focus on private land. The fire history for the Eastern Tiers reported in this thesis forms a platform of knowledge from which future research can be crafted. Such endeavours would be enormously strengthened by the involvement of work from other disciplines such as anthropology and ethnohistory (Drew & Henne 2006).

Whilst not conclusively demonstrated, variability in the fire regime may nevertheless be the key to maintaining biodiversity in dry forest systems (e.g. Landres *et al.* 1999; Walshe & Williams 2003). However, with the current uncertain climate of change upon us, the capacity to implement such regimes may be beyond our control. As Jackson (1999 p.34) so succinctly pointed out *"Whereas lightning is an important source of fire on mainland Australia (Gill 1981a), the vast majority of fires in Tasmania are man-made."*

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Appendix 1

Cross dating results for the averaged series from the young trees.

```
*******************************************************************
*** TSAP CROSS-DATING     ***
-> All results of sample and references:
-> MinLeftOverlap=50 / MinRightOverlap=50
-> Chrono signature conditions: Density>4 / Internal Glk>50
-> Results listed for each reference-sample pair.
-> List all results
-> Match acceptance: logical OR - connection of threshold values,
   one of the following threshold values has to be exceeded.
   Threshold conditions:
   Glk%>50  SGlk%>50  SSGlk%>50  TV>5.0  CrC>0.5  CDI>10
-------------------------------------------------------------------

Sample    (=HalfCh): c12ten av                     0      138  1867  2004
Reference (=HalfCh): c12ten av                     0      138  1867  2004
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Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c12ten av	138	100	***	1000	100	100.0	100.0	100.0	1867	2004
c12ten av	136	43		21	16	1.8	6.6	3.2	1865	2002
c12ten av	136	43		21	16	1.8	6.6	3.2	1869	2006
c12ten av	127	56		12	5	0.5	2.4	2.0	1856	1993
c12ten av	137	39		9	43	5.6	1.9	2.8	1868	2005
c12ten av	137	39		9	43	5.6	1.9	2.8	1866	2003
c12ten av	121	53		8	8	0.9	1.5	1.5	1850	1987
c12ten av	116	57		7	10	1.1	1.0	1.7	1845	1982
c12ten av	135	54		7	22	2.6	1.1	1.5	1864	2001
c12ten av	132	55		6	15	1.7	1.1	1.0	1861	1998
c12ten av	115	50		6	9	0.9	1.2	1.3	1844	1981
c12ten av	118	54		5	-6	0.7	0.9	1.0	1847	1984
c12ten av	128	53		5	-10	1.1	0.8	1.1	1857	1994
c12ten av	126	52		4	-6	0.7	0.6	0.8	1855	1992
c12ten av	130	52		4	-1	0.2	0.5	1.1	1859	1996
c12ten av	125	50		4	-5	0.5	1.1	0.6	1854	1991
c12ten av	123	51		1	-3	0.3	0.3	0.3	1852	1989
c12ten av	122	50		1	1	0.1	0.3	0.0	1851	1988
c12ten av	133	55		0	11	1.2	0.1	0.0	1862	1999

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Sample    (=HalfCh): 003Aobl av                    0      122  1881  2002
Reference (=HalfCh): c12ten av                     0      138  1867  2004
```

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003Aobl av	122	53		10	30	3.5	1.5	2.5	1876	1997
003Aobl av	122	58	*	7	23	2.5	1.1	1.5	1874	1995
003Aobl av	114	55		7	30	3.3	1.7	0.9	1859	1980
003Aobl av	121	57		6	25	2.8	1.1	1.0	1866	1987
003Aobl av	117	50		6	22	2.5	1.1	1.2	1862	1983
003Aobl av	119	51		5	17	1.8	1.3	0.9	1864	1985
003Aobl av	122	52		4	23	2.5	0.4	1.1	1879	2000
003Aobl av	121	52		4	4	0.4	0.5	1.0	1884	2005
003Aobl av	120	52		3	24	2.7	1.0	0.1	1865	1986
003Aobl av	122	51		3	19	2.1	0.7	0.5	1867	1988

003Aobl av	122	51		3	15	1.7	0.2	1.0	1882	2003
003Aobl av	122	51		3	17	1.9	0.7	0.5	1871	1992
003Aobl av	115	50		3	28	3.1	0.6	0.5	1860	1981
003Aobl av	122	52		2	16	1.8	0.6	0.3	1881	2002
003Aobl av	122	51		2	31	3.6	0.6	0.2	1877	1998
003Aobl av	122	50		2	18	2.0	0.2	0.5	1880	2001
003Aobl av	122	54		1	21	2.4	0.4	0.1	1869	1990
003Aobl av	122	52		1	22	2.5	0.4	0.1	1873	1994

Sample (=HalfCh): 003obl av 0 131 1872 2002
Reference (=HalfCh): c12ten av 0 138 1867 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003obl av	115	60	*	19	38	4.4	3.5	3.4	1851	1981
003obl av	129	57	*	13	25	2.9	2.6	1.9	1865	1995
003obl av	131	56		10	27	3.2	1.8	1.9	1868	1998
003obl av	131	60	*	8	14	1.6	1.3	1.3	1874	2004
003obl av	125	52		7	21	2.4	1.6	1.0	1861	1991
003obl av	131	52		6	15	1.8	1.0	1.4	1871	2001
003obl av	128	50		6	13	1.4	1.1	1.4	1864	1994
003obl av	119	58	*	5	28	3.2	0.8	1.0	1855	1985
003obl av	121	56		5	30	3.5	0.7	1.2	1857	1987
003obl av	122	52		3	22	2.5	0.7	0.6	1858	1988
003obl av	131	50		3	12	1.3	0.4	0.7	1872	2002
003obl av	124	52		2	21	2.3	0.5	0.2	1860	1990
003obl av	131	52		2	14	1.6	0.6	0.3	1870	2000
003obl av	129	54		1	10	1.2	0.1	0.2	1876	2006

Sample (=HalfCh): 004ten av 0 77 1926 2002
Reference (=HalfCh): c12ten av 0 138 1867 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
004ten av	77	61	*	14	13	1.1	2.4	2.1	1920	1996
004ten av	77	50		11	19	1.7	2.9	1.7	1927	2003
004ten av	77	42		10	-28	2.5	2.9	2.0	1918	1994
004ten av	75	57		9	15	1.3	1.7	1.4	1930	2006
004ten av	76	52		8	-4	0.3	1.7	1.5	1929	2005
004ten av	77	57		6	-7	0.6	1.3	1.0	1910	1986
004ten av	77	51		6	-19	1.7	1.5	0.8	1916	1992
004ten av	77	51		6	2	0.2	1.1	1.4	1906	1982
004ten av	77	54		5	-13	1.2	1.0	0.9	1913	1989
004ten av	77	53		4	3	0.3	1.0	0.5	1923	1999
004ten av	77	53		4	-4	0.4	1.1	0.5	1922	1998
004ten av	77	51		4	-17	1.5	0.6	0.8	1909	1985
004ten av	77	50		4	-9	0.8	0.8	0.8	1907	1983
004ten av	77	51		3	-27	2.4	0.6	0.7	1914	1990
004ten av	77	50		3	-16	1.4	0.5	0.5	1911	1987
004ten av	77	55		2	-3	0.3	0.5	0.2	1905	1981
004ten av	77	53		2	6	0.5	0.3	0.4	1926	2002
004ten av	77	50		2	-16	1.4	0.5	0.3	1912	1988
004ten av	77	51		1	-7	0.6	0.2	0.1	1919	1995
004ten av	77	50		1	-8	0.7	0.2	0.2	1904	1980
004ten av	77	53		0	-1	0.1	0.0	0.1	1924	2000

Sample (=HalfCh): 006pul av 0 134 1869 2002

Reference (=HalfCh): c12ten av 0 138 1867 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
006pul av	134	55		12	35	4.3	2.1	2.3	1869	2002
006pul av	131	57	*	10	7	0.9	1.9	1.5	1864	1997
006pul av	132	56		10	39	4.8	1.7	1.9	1873	2006
006pul av	115	54		10	-3	0.4	2.3	1.8	1848	1981
006pul av	133	55		7	32	3.9	1.1	1.3	1872	2005
006pul av	117	52		7	4	0.4	1.5	1.3	1850	1983
006pul av	128	60	**	6	2	0.3	0.9	1.0	1861	1994
006pul av	125	54		6	13	1.5	1.4	0.8	1858	1991
006pul av	124	52		5	11	1.2	1.1	0.9	1857	1990
006pul av	126	52		4	2	0.2	1.1	0.5	1859	1992
006pul av	116	54		3	4	0.4	0.6	0.5	1849	1982
006pul av	120	53		3	8	0.8	1.1	0.3	1853	1986
006pul av	119	51		3	7	0.7	0.4	0.9	1852	1985
006pul av	123	51		3	5	0.6	0.7	0.3	1856	1989
006pul av	114	58		2	10	1.0	0.2	0.4	1847	1980
006pul av	133	53		2	12	1.4	0.2	0.4	1866	1999
006pul av	134	51		2	20	2.3	0.7	0.0	1867	2000
006pul av	134	51		2	32	3.9	0.7	0.1	1870	2003

Sample (=HalfCh): 007ten av 0 94 1910 2003
Reference (=HalfCh): c12ten av 0 138 1867 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
007ten av	94	58		11	22	2.2	2.1	1.5	1887	1980
007ten av	94	61	*	9	14	1.3	1.7	1.3	1890	1983
007ten av	94	58		9	26	2.6	1.7	1.3	1904	1997
007ten av	94	61	*	8	12	1.2	1.6	1.0	1897	1990
007ten av	94	57		8	14	1.4	1.3	1.4	1907	2000
007ten av	94	54		8	-1	0.1	1.8	1.1	1895	1988
007ten av	93	55		6	7	0.7	0.9	1.2	1912	2005
007ten av	94	50		6	11	1.1	1.7	0.8	1893	1986
007ten av	94	59	*	3	11	1.1	0.3	0.8	1910	2003
007ten av	94	52		3	19	1.8	0.3	0.7	1903	1996
007ten av	94	50		3	9	0.9	1.1	0.3	1888	1981
007ten av	94	52		2	14	1.4	0.3	0.4	1902	1995
007ten av	94	51		2	11	1.0	0.7	0.3	1898	1991
007ten av	94	52		1	9	0.9	0.1	0.3	1909	2002
007ten av	94	50		1	11	1.1	0.0	0.2	1900	1993

Sample (=HalfCh): 008ten av 0 99 1904 2002
Reference (=HalfCh): c12ten av 0 138 1867 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
008ten av	99	62	**	15	7	0.7	2.4	2.3	1889	1987
008ten av	99	54		13	17	1.7	2.6	2.1	1902	2000
008ten av	99	54		12	8	0.8	2.5	1.8	1885	1983
008ten av	99	53		12	-12	1.2	2.9	1.7	1887	1985
008ten av	99	50		9	-2	0.2	2.1	1.4	1901	1999
008ten av	99	55		8	13	1.3	1.4	1.6	1906	2004
008ten av	99	52		8	3	0.2	1.8	1.1	1904	2002

008ten av	99	50		8	-25	2.6	1.5	1.5	1893	1991
008ten av	99	53		7	5	0.5	1.9	0.5	1896	1994
008ten av	99	50		7	2	0.2	1.8	1.1	1899	1997
008ten av	99	57		6	-4	0.4	1.2	1.0	1895	1993
008ten av	99	50		6	-10	1.0	1.4	1.0	1898	1996
008ten av	99	51		5	17	1.7	1.1	0.9	1903	2001
008ten av	99	53		3	-6	0.6	1.0	0.2	1897	1995
008ten av	99	53		3	-5	0.5	0.7	0.6	1883	1981
008ten av	99	51		1	-17	1.7	0.2	0.3	1892	1990
008ten av	99	50		0	-4	0.4	0.0	0.0	1886	1984

Sample (=HalfCh): 009ten av 0 74 1929 2002
Reference (=HalfCh): c12ten av 0 138 1867 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
009ten av	74	65	**	17	29	2.5	2.7	2.4	1916	1989
009ten av	74	65	**	17	15	1.2	2.6	2.5	1921	1994
009ten av	73	68	**	13	12	1.0	2.1	1.8	1932	2005
009ten av	74	42		12	-23	2.0	3.1	2.8	1919	1992
009ten av	74	53		10	5	0.4	1.6	2.1	1929	2002
009ten av	72	56		7	9	0.7	1.4	1.2	1933	2006
009ten av	74	61	*	6	15	1.3	0.7	1.3	1913	1986
009ten av	74	53		6	28	2.5	1.0	1.1	1910	1983
009ten av	74	50		5	12	1.0	1.1	1.1	1915	1988
009ten av	74	50		4	18	1.6	1.1	0.4	1922	1995
009ten av	74	50		4	9	0.8	1.0	0.6	1907	1980
009ten av	74	63	*	3	8	0.6	0.4	0.5	1927	2000
009ten av	74	56		2	12	1.0	0.7	0.2	1926	1999
009ten av	74	53		2	8	0.7	0.3	0.4	1925	1998
009ten av	74	53		2	22	2.0	0.3	0.4	1908	1981
009ten av	74	53		2	-8	0.7	0.3	0.6	1920	1993

Sample (=HalfCh): c04obl av 0 155 1848 2002
Reference (=HalfCh): c12ten av 0 138 1867 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c04obl av	132	47		11	-9	1.1	2.7	2.1	1844	1998
c04obl av	117	52		8	-2	0.2	1.8	1.3	1829	1983
c04obl av	130	52		6	-3	0.4	1.6	0.7	1842	1996
c04obl av	115	50		6	10	1.1	1.3	1.2	1827	1981
c04obl av	119	56		5	6	0.7	1.4	0.4	1831	1985
c04obl av	126	56		4	4	0.4	0.9	0.7	1838	1992
c04obl av	134	53		4	6	0.7	1.0	0.6	1846	2000
c04obl av	136	57	*	3	14	1.6	0.7	0.4	1848	2002
c04obl av	128	52		3	-10	1.1	0.8	0.2	1840	1994
c04obl av	129	51		3	-5	0.6	1.0	0.3	1841	1995
c04obl av	120	50		3	5	0.6	0.9	0.5	1832	1986
c04obl av	133	50		3	-1	0.1	0.7	0.6	1845	1999
c04obl av	138	57	*	2	20	2.4	0.2	0.6	1851	2005
c04obl av	124	52		2	8	0.9	0.8	0.1	1836	1990
c04obl av	118	51		2	0	0.0	0.7	0.3	1830	1984
c04obl av	123	56		1	3	0.3	0.1	0.1	1835	1989
c04obl av	131	53		1	-6	0.6	0.4	0.1	1843	1997
c04obl av	114	55		0	11	1.2	0.0	0.2	1826	1980

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Sample    (=HalfCh): c06pul av                        0      130  1873  2002
Reference (=HalfCh): c12ten av                        0      138  1867  2004

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
c06pul av   130  64 ***    20   15   1.7   2.7   3.6   1868   1997
c06pul av   130  43        15   -9   1.0   3.4   3.8   1869   1998
c06pul av   130  46        11   -5   0.6   2.2   2.4   1875   2004
c06pul av   127  41        10    1   0.1   2.5   2.3   1864   1993
c06pul av   125  56         9   22   2.5   2.1   1.4   1862   1991
c06pul av   130  54         8    3   0.4   1.2   1.7   1874   2003
c06pul av   130  52         7    3   0.3   1.5   1.0   1871   2000
c06pul av   120  60 *       5   16   1.8   0.5   1.0   1857   1986
c06pul av   129  56         5   10   1.2   0.7   1.2   1866   1995
c06pul av   122  54         4   19   2.2   0.9   0.8   1859   1988
c06pul av   130  52         4    4   0.5   1.1   0.3   1873   2002
c06pul av   126  54         3    5   0.6   0.7   0.4   1863   1992
c06pul av   117  54         3    2   0.3   0.8   0.5   1854   1983
c06pul av   118  51         3    7   0.7   0.7   0.6   1855   1984
c06pul av   123  50         3   23   2.6   0.2   1.0   1860   1989
c06pul av   130  52         2   -3   0.3   0.1   0.8   1870   1999
c06pul av   115  50         0  -11   1.2   0.1   0.0   1852   1981
-----------------------------------------------------------------

Sample    (=HalfCh): c07obl av                        0      114  1889  2002
Reference (=HalfCh): c12ten av                        0      138  1867  2004

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
c07obl av   114  60 *      12   27   2.9   2.1   1.9   1875   1988
c07obl av   114  50         8   20   2.1   2.2   1.2   1867   1980
c07obl av   114  57         7   29   3.2   1.3   1.1   1876   1989
c07obl av   114  50         7   41   4.8   1.7   1.2   1881   1994
c07obl av   114  50         6    9   1.0   1.0   1.5   1885   1998
c07obl av   114  56         5   23   2.5   1.0   0.7   1890   2003
c07obl av   114  54         5   21   2.2   1.1   0.6   1878   1991
c07obl av   114  52         5   26   2.8   0.9   1.1   1883   1996
c07obl av   112  50         5   29   3.1   1.2   0.6   1893   2006
c07obl av   114  52         4   15   1.6   0.9   0.8   1873   1986
c07obl av   114  51         4   11   1.2   0.7   1.0   1870   1983
c07obl av   114  51         3   37   4.2   0.7   0.6   1880   1993
c07obl av   114  50         3   14   1.5   0.8   0.4   1891   2004
c07obl av   114  58         2   31   3.5   0.2   0.7   1882   1995
c07obl av   114  58         2   12   1.3   0.3   0.5   1868   1981
c07obl av   114  50         2   26   2.8   0.7   0.3   1879   1992
c07obl av   113  50         2   18   1.9   0.7   0.0   1892   2005
c07obl av   114  55         1   22   2.4   0.1   0.3   1888   2001
-----------------------------------------------------------------

Sample    (=HalfCh): c08ten av                        0       93  1910  2002
Reference (=HalfCh): c12ten av                        0      138  1867  2004

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
c08ten av    93  68 ***    12   12   1.2   2.1   1.6   1898   1990
c08ten av    93  58        12   21   2.1   2.4   1.7   1888   1980
c08ten av    93  55        10   18   1.7   1.9   1.7   1908   2000
```

c08ten av	93	54		7	0	0.0	1.9	0.6	1896	1988
c08ten av	93	53		5	12	1.1	0.7	1.1	1901	1993
c08ten av	93	55		4	24	2.4	1.4	0.2	1905	1997
c08ten av	93	55		3	12	1.1	0.1	0.8	1911	2003
c08ten av	93	54		3	13	1.2	0.6	0.4	1903	1995
c08ten av	92	53		3	6	0.6	0.8	0.4	1913	2005
c08ten av	93	50		3	11	1.0	0.9	0.3	1906	1998
c08ten av	93	50		3	9	0.9	0.8	0.5	1889	1981
c08ten av	93	57		2	10	1.0	0.6	0.2	1891	1983
c08ten av	93	52		2	20	2.0	0.4	0.5	1904	1996
c08ten av	93	51		2	10	0.9	0.4	0.4	1910	2002
c08ten av	93	55		1	11	1.1	0.2	0.1	1909	2001
c08ten av	93	50		1	7	0.6	0.2	0.4	1893	1985

Sample (=HalfCh): c12ten av 0 138 1867 2004
Reference (=HalfCh): 003Aobl av 0 122 1881 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c12ten av	107	56		8	12	1.2	1.9	1.0	1850	1987
c12ten av	115	55		7	13	1.4	1.7	1.1	1858	1995
c12ten av	110	53		7	11	1.2	1.5	1.2	1853	1990
c12ten av	104	58		5	17	1.8	0.8	1.2	1847	1984
c12ten av	114	56		4	12	1.3	1.2	0.2	1857	1994
c12ten av	106	54		4	15	1.5	0.5	0.9	1849	1986
c12ten av	122	52		4	23	2.5	0.4	1.1	1869	2006
c12ten av	121	52		4	4	0.4	0.5	1.0	1864	2001
c12ten av	102	52		3	15	1.5	0.5	0.7	1845	1982
c12ten av	122	51		3	15	1.7	0.2	1.0	1866	2003
c12ten av	113	52		2	10	1.1	0.5	0.1	1856	1993
c12ten av	122	52		2	16	1.8	0.6	0.3	1867	2004
c12ten av	112	51		2	9	0.9	1.0	0.0	1855	1992
c12ten av	122	50		2	18	2.0	0.2	0.5	1868	2005
c12ten av	100	52		1	8	0.8	0.3	0.1	1843	1980
c12ten av	101	52		1	11	1.1	0.2	0.1	1844	1981

Sample (=HalfCh): 003Aobl av 0 122 1881 2002
Reference (=HalfCh): 003Aobl av 0 122 1881 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003Aobl av	122	100	***	1000	100	100.0	100.0	100.0	1881	2002
003Aobl av	112	59	*	15	56	7.1	2.4	2.8	1871	1992
003Aobl av	121	42		13	75	12.2	2.3	4.0	1880	2001
003Aobl av	121	42		13	75	12.2	2.3	4.0	1882	2003
003Aobl av	100	58		11	45	5.0	2.1	2.0	1859	1980
003Aobl av	117	52		10	41	4.9	1.8	2.0	1876	1997
003Aobl av	120	49		8	64	9.0	2.7	0.4	1879	2000
003Aobl av	120	49		8	64	9.0	2.7	0.4	1883	2004
003Aobl av	118	41		8	44	5.3	1.5	2.5	1877	1998
003Aobl av	118	41		8	44	5.3	1.5	2.5	1885	2006
003Aobl av	104	53		6	23	2.4	0.5	1.8	1863	1984
003Aobl av	114	52		6	45	5.3	1.0	1.5	1873	1994
003Aobl av	110	51		5	56	7.0	0.5	1.7	1869	1990
003Aobl av	111	43		5	54	6.7	1.1	1.1	1870	1991
003Aobl av	101	53		4	32	3.4	1.2	0.6	1860	1981

003Aobl av	109	48		4	54	6.7	1.0	1.0	1868	1989
003Aobl av	115	58	*	3	41	4.7	0.3	0.8	1874	1995
003Aobl av	107	53		2	44	5.0	0.8	0.0	1866	1987
003Aobl av	108	53		2	49	5.8	0.3	0.5	1867	1988
003Aobl av	106	52		2	36	3.9	0.4	0.3	1865	1986
003Aobl av	105	50		2	27	2.9	0.2	0.8	1864	1985
003Aobl av	119	51		1	53	6.8	0.1	0.2	1884	2005
003Aobl av	119	51		1	53	6.8	0.1	0.2	1878	1999
003Aobl av	113	47		0	51	6.2	0.0	0.1	1872	1993

Sample (=HalfCh): 003obl av 0 131 1872 2002
Reference (=HalfCh): 003Aobl av 0 122 1881 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003obl av	122	50		10	44	5.4	1.8	2.0	1876	2006
003obl av	120	47		8	50	6.3	1.7	1.8	1870	2000
003obl av	104	58	*	6	40	4.4	1.0	1.3	1854	1984
003obl av	119	53		6	44	5.3	1.3	1.1	1869	1999
003obl av	114	52		6	40	4.6	1.5	0.7	1864	1994
003obl av	105	50		6	44	4.9	1.8	0.7	1855	1985
003obl av	113	50		6	32	3.6	1.2	1.2	1863	1993
003obl av	115	52		5	42	4.9	1.3	0.6	1865	1995
003obl av	122	52		4	42	5.0	0.4	1.1	1875	2005
003obl av	107	52		3	39	4.3	0.9	0.5	1857	1987
003obl av	121	50		3	48	6.0	1.3	0.0	1871	2001
003obl av	100	59	*	2	36	3.8	0.0	0.6	1850	1980
003obl av	116	57		2	37	4.2	0.5	0.1	1866	1996
003obl av	118	55		2	40	4.8	0.7	0.0	1868	1998
003obl av	106	53		2	43	4.8	0.6	0.2	1856	1986
003obl av	122	50		2	40	4.8	0.5	0.3	1874	2004
003obl av	122	52		1	45	5.5	0.0	0.4	1872	2002
003obl av	108	51		1	38	4.2	0.2	0.0	1858	1988
003obl av	109	50		1	41	4.6	0.2	0.2	1859	1989

Sample (=HalfCh): 004ten av 0 77 1926 2002
Reference (=HalfCh): 003Aobl av 0 122 1881 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
004ten av	77	56		10	21	1.8	1.7	1.7	1910	1986
004ten av	77	45		10	-9	0.8	2.4	2.2	1913	1989
004ten av	77	52		9	-29	2.6	1.7	1.6	1916	1992
004ten av	77	56		8	5	0.4	1.5	1.4	1925	2001
004ten av	77	59		7	-19	1.6	1.1	1.3	1921	1997
004ten av	77	57		6	2	0.2	1.2	0.8	1924	2000
004ten av	77	57		6	17	1.5	0.4	1.8	1912	1988
004ten av	77	51		5	-25	2.2	1.3	0.7	1917	1993
004ten av	77	51		3	20	1.7	0.6	0.5	1911	1987
004ten av	77	56		2	-14	1.2	0.4	0.3	1915	1991
004ten av	77	53		2	-9	0.8	0.6	0.2	1923	1999
004ten av	77	53		2	-14	1.2	0.3	0.4	1926	2002
004ten av	73	52		2	-33	2.9	0.2	0.6	1930	2006
004ten av	74	50		2	-36	3.3	0.3	0.4	1929	2005
004ten av	77	50		2	-28	2.6	0.8	0.2	1920	1996
004ten av	77	56		0	9	0.7	0.0	0.1	1909	1985
004ten av	77	52		0	-18	1.5	0.1	0.0	1907	1983

Sample	(=HalfCh): 006pul av	0	134	1869	2002
Reference	(=HalfCh): 003Aobl av	0	122	1881	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
006pul av	116	53		8	33	3.8	1.4	1.5	1863	1996
006pul av	108	51		8	38	4.2	1.4	1.7	1855	1988
006pul av	122	51		8	51	6.5	1.4	1.8	1871	2004
006pul av	101	56		7	42	4.6	1.0	1.6	1848	1981
006pul av	115	54		7	39	4.5	1.2	1.4	1862	1995
006pul av	109	47		7	45	5.2	1.4	1.8	1856	1989
006pul av	110	50		6	54	6.6	1.0	1.6	1857	1990
006pul av	111	57		5	60	7.7	1.2	0.8	1858	1991
006pul av	122	54		3	50	6.4	0.6	0.4	1873	2006
006pul av	118	53		3	35	4.1	1.2	0.0	1865	1998
006pul av	117	56		2	34	3.9	0.5	0.4	1864	1997
006pul av	122	54		2	50	6.3	0.5	0.1	1872	2005
006pul av	122	53		2	43	5.2	0.4	0.5	1870	2003
006pul av	102	52		2	43	4.7	0.3	0.7	1849	1982
006pul av	112	41		2	50	6.1	0.7	0.1	1859	1992
006pul av	103	55		1	34	3.6	0.0	0.4	1850	1983
006pul av	113	54		1	46	5.5	0.3	0.3	1860	1993
006pul av	121	53		0	36	4.2	0.0	0.1	1868	2001

Sample	(=HalfCh): 007ten av	0	94	1910	2003
Reference	(=HalfCh): 003Aobl av	0	122	1881	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
007ten av	94	58		17	33	3.4	3.5	2.6	1906	1999
007ten av	94	55		13	20	1.9	1.8	2.7	1909	2002
007ten av	94	52		13	40	4.2	2.2	2.8	1894	1987
007ten av	94	46		11	30	3.0	2.0	2.8	1893	1986
007ten av	94	55		10	25	2.5	1.6	2.2	1887	1980
007ten av	94	44		10	-1	0.1	2.1	2.6	1903	1996
007ten av	94	65	**	9	31	3.1	1.1	1.7	1897	1990
007ten av	94	57		7	31	3.1	0.5	2.0	1892	1985
007ten av	94	51		7	20	2.0	0.3	2.4	1899	1992
007ten av	94	54		6	5	0.4	1.1	0.9	1904	1997
007ten av	91	62	*	5	5	0.5	1.4	0.2	1912	2005
007ten av	94	58		3	27	2.7	0.1	1.0	1890	1983
007ten av	94	55		3	14	1.4	0.2	0.7	1905	1998
007ten av	94	54		3	18	1.7	0.4	0.8	1900	1993
007ten av	94	55		2	6	0.5	0.6	0.2	1902	1995
007ten av	92	51		2	10	0.9	0.1	0.6	1911	2004
007ten av	94	50		2	26	2.6	0.6	0.2	1907	2000
007ten av	90	50		1	-2	0.2	0.3	0.1	1913	2006

Sample	(=HalfCh): 008ten av	0	99	1904	2002
Reference	(=HalfCh): 003Aobl av	0	122	1881	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
008ten av	99	61	*	12	-28	2.8	2.0	2.0	1886	1984
008ten av	99	54		12	-16	1.6	2.4	2.1	1896	1994
008ten av	99	59	*	10	-18	1.8	1.4	2.0	1900	1998

008ten av	99	50		5	-25	2.5	0.6	1.3	1901	1999
008ten av	99	49		5	-46	5.1	1.0	1.1	1882	1980
008ten av	99	48		5	-47	5.3	1.0	1.0	1892	1990
008ten av	99	53		4	-40	4.4	1.1	0.3	1884	1982
008ten av	99	52		4	-20	2.1	0.7	0.7	1902	2000
008ten av	99	55		3	-43	4.7	0.7	0.3	1890	1988
008ten av	99	54		3	-40	4.3	0.8	0.4	1893	1991
008ten av	99	53		3	-19	1.9	0.8	0.4	1898	1996
008ten av	97	52		3	-6	0.6	1.0	0.2	1906	2004
008ten av	96	51		3	-2	0.2	0.7	0.4	1907	2005
008ten av	99	50		3	-36	3.8	0.8	0.2	1888	1986
008ten av	99	59	*	2	-23	2.4	0.3	0.2	1903	2001
008ten av	99	55		2	-39	4.1	0.0	0.6	1889	1987
008ten av	98	55		2	-17	1.7	0.5	0.1	1905	2003
008ten av	99	51		2	-31	3.2	0.6	0.1	1885	1983
008ten av	99	40		2	-48	5.4	0.5	0.4	1891	1989
008ten av	99	50		0	-31	3.2	0.0	0.2	1887	1985

Sample	(=HalfCh): 009ten av	0	74	1929	2002
Reference	(=HalfCh): 003Aobl av	0	122	1881	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
009ten av	74	60	*	19	44	4.1	3.6	2.8	1929	2002
009ten av	74	56		6	21	1.8	1.0	1.0	1926	1999
009ten av	74	54		6	23	2.0	1.2	1.1	1920	1993
009ten av	73	50		6	46	4.4	1.4	1.1	1930	2003
009ten av	74	58		5	14	1.2	1.1	0.6	1912	1985
009ten av	74	55		5	26	2.2	0.9	1.1	1915	1988
009ten av	74	53		4	22	1.9	1.3	0.3	1928	2001
009ten av	74	51		4	6	0.5	0.8	0.6	1911	1984
009ten av	74	60	*	3	27	2.4	0.8	0.4	1921	1994
009ten av	74	59		3	25	2.2	0.5	0.3	1916	1989
009ten av	74	53		3	5	0.4	1.0	0.2	1908	1981
009ten av	74	53		3	19	1.7	0.4	0.6	1913	1986
009ten av	74	51		2	19	1.6	0.6	0.4	1924	1997
009ten av	74	54		1	24	2.1	0.3	0.1	1922	1995
009ten av	74	51		1	19	1.6	0.0	0.2	1923	1996
009ten av	71	51		1	23	1.9	0.5	0.1	1932	2005

Sample	(=HalfCh): c04obl av	0	155	1848	2002
Reference	(=HalfCh): 003Aobl av	0	122	1881	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c04obl av	116	57		9	34	3.9	1.7	1.6	1842	1996
c04obl av	111	56		9	43	5.0	1.2	2.2	1837	1991
c04obl av	121	55		6	25	2.8	1.2	0.9	1847	2001
c04obl av	101	52		5	36	3.9	1.1	1.1	1827	1981
c04obl av	109	53		4	38	4.3	1.2	0.3	1835	1989
c04obl av	122	50		4	23	2.6	0.6	1.0	1851	2005
c04obl av	117	56		3	23	2.6	0.6	0.7	1843	1997
c04obl av	102	55		3	35	3.8	0.4	0.6	1828	1982
c04obl av	105	51		3	30	3.2	0.1	1.3	1831	1985
c04obl av	122	58	*	2	25	2.9	0.5	0.0	1850	2004
c04obl av	106	54		2	31	3.3	0.3	0.4	1832	1986
c04obl av	114	52		2	40	4.6	0.2	0.6	1840	1994

```
c04obl av   100  52         1   36   3.8   0.3   0.0   1826   1980
c04obl av   108  51         1   37   4.1   0.2   0.2   1834   1988
c04obl av   103  50         1   33   3.5   0.0   0.4   1829   1983
-------------------------------------------------------------------

Sample    (=HalfCh): c06pul av                         0       130  1873  2002
Reference (=HalfCh): 003Aobl av                        0       122  1881  2002

  Sample    OVL Glk GSL   CDI  %CC     TV  TVBP  TVH   DateL  DateR
c06pul av   122  53        12   17   1.9   2.2   2.2   1873   2002
c06pul av   110  53         9    7   0.7   1.9   1.5   1861   1990
c06pul av   108  58         6   13   1.4   1.5   0.9   1859   1988
c06pul av   120  55         6   15   1.7   1.6   0.5   1871   2000
c06pul av   122  53         6   23   2.6   0.6   1.6   1875   2004
c06pul av   116  51         6   33   3.7   1.3   1.3   1867   1996
c06pul av   106  55         5   -3   0.3   0.5   1.6   1857   1986
c06pul av   100  52         4  -10   1.0   0.6   0.9   1851   1980
c06pul av   111  53         3   14   1.5   0.4   0.6   1862   1991
c06pul av   122  53         2   22   2.5   0.6   0.1   1877   2006
c06pul av   118  57         1   28   3.1   0.2   0.1   1869   1998
c06pul av   113  53         1   20   2.2   0.3   0.3   1864   1993
c06pul av   102  55         0   -7   0.7   0.1   0.0   1853   1982
c06pul av   103  50         0   -9   1.0   0.1   0.2   1854   1983
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Sample    (=HalfCh): c07obl av                         0       114  1889  2002
Reference (=HalfCh): 003Aobl av                        0       122  1881  2002

  Sample    OVL Glk GSL   CDI  %CC     TV  TVBP  TVH   DateL  DateR
c07obl av   102  44        10    8   0.8   2.6   2.1   1869   1982
c07obl av   114  42        10   18   2.0   2.8   2.2   1884   1997
c07obl av   101  52         9   11   1.1   1.9   1.6   1868   1981
c07obl av   114  51         9   14   1.5   2.1   1.5   1882   1995
c07obl av   104  55         7   15   1.6   1.4   1.1   1871   1984
c07obl av   111  57         6   26   2.8   1.0   1.1   1892   2005
c07obl av   111  50         5    7   0.8   0.9   1.2   1878   1991
c07obl av   105  55         4   16   1.7   1.0   0.4   1872   1985
c07obl av   114  53         4   18   1.9   0.9   0.8   1883   1996
c07obl av   100  52         4   11   1.1   1.0   0.4   1867   1980
c07obl av   106  56         3   16   1.6   0.2   0.9   1873   1986
c07obl av   103  52         3   12   1.2   1.3   0.0   1870   1983
c07obl av   113  52         3   13   1.3   0.5   0.7   1880   1993
c07obl av   114  52         2   19   2.0   0.4   0.2   1888   2001
c07obl av   112  51         2   12   1.3   0.3   0.5   1879   1992
c07obl av   114  50         2   21   2.3   0.5   0.3   1887   2000
c07obl av   114  54         1   22   2.4   0.1   0.2   1885   1998
c07obl av   114  53         0   15   1.6   0.1   0.0   1889   2002
-------------------------------------------------------------------

Sample    (=HalfCh): c08ten av                         0        93  1910  2002
Reference (=HalfCh): 003Aobl av                        0       122  1881  2002

  Sample    OVL Glk GSL   CDI  %CC     TV  TVBP  TVH   DateL  DateR
c08ten av    90  63 **     19    9   0.9   3.0   3.2   1913   2005
c08ten av    93  53        13   41   4.2   2.7   2.1   1895   1987
c08ten av    93  53        11   21   2.1   2.5   1.6   1910   2002
c08ten av    91  48        11    3   0.3   2.3   2.6   1912   2004
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c08ten av	93	53		10	30	3.0	2.4	1.5	1907	1999
c08ten av	93	57		9	26	2.6	1.4	1.9	1888	1980
c08ten av	93	52		7	29	2.8	1.5	1.4	1893	1985
c08ten av	93	55		5	20	1.9	1.1	0.8	1901	1993
c08ten av	93	57		4	26	2.6	0.3	1.1	1891	1983
c08ten av	93	59	*	2	29	2.9	0.3	0.2	1898	1990
c08ten av	93	53		2	3	0.3	0.8	0.1	1905	1997
c08ten av	93	51		2	28	2.8	0.3	0.4	1908	2000
c08ten av	93	52		1	2	0.2	0.2	0.3	1903	1995
c08ten av	93	59	*	0	13	1.2	0.1	0.0	1906	1998
c08ten av	93	52		0	20	1.9	0.1	0.1	1900	1992

Sample	(=HalfCh): c12ten av	0	138	1867	2004
Reference	(=HalfCh): 003obl av	0	131	1872	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c12ten av	131	60	*	8	14	1.6	1.3	1.3	1865	2002
c12ten av	123	58	*	8	13	1.5	0.8	2.1	1857	1994
c12ten av	121	57		8	3	0.3	1.3	1.4	1855	1992
c12ten av	125	55		7	8	0.9	1.4	1.0	1859	1996
c12ten av	112	54		6	8	0.9	1.2	1.0	1846	1983
c12ten av	131	52		6	15	1.8	1.0	1.4	1868	2005
c12ten av	113	51		6	11	1.2	1.5	1.0	1847	1984
c12ten av	120	50		4	-3	0.3	1.0	0.6	1854	1991
c12ten av	115	55		3	-6	0.6	0.2	0.9	1849	1986
c12ten av	131	50		3	12	1.3	0.4	0.7	1867	2004
c12ten av	127	54		2	12	1.3	0.4	0.3	1861	1998
c12ten av	111	53		2	0	0.0	0.6	0.3	1845	1982
c12ten av	131	52		2	14	1.6	0.6	0.3	1869	2006
c12ten av	110	51		2	0	0.0	0.2	0.5	1844	1981
c12ten av	129	54		1	10	1.2	0.1	0.2	1863	2000
c12ten av	117	53		1	-15	1.6	0.1	0.4	1851	1988

Sample	(=HalfCh): 003Aobl av	0	122	1881	2002
Reference	(=HalfCh): 003obl av	0	131	1872	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003Aobl av	122	50		10	44	5.4	1.8	2.0	1877	1998
003Aobl av	112	58	*	9	44	5.2	1.1	1.9	1862	1983
003Aobl av	122	59	*	8	58	7.8	0.9	1.8	1872	1993
003Aobl av	120	47		8	50	6.3	1.7	1.8	1883	2004
003Aobl av	120	56		6	59	8.0	0.9	1.2	1870	1991
003Aobl av	119	53		6	44	5.3	1.3	1.1	1884	2005
003Aobl av	121	49		5	54	7.0	1.0	1.1	1871	1992
003Aobl av	117	46		5	47	5.7	1.2	0.9	1867	1988
003Aobl av	114	55		4	40	4.6	0.7	0.6	1864	1985
003Aobl av	122	52		4	42	5.0	0.4	1.1	1878	1999
003Aobl av	122	52		3	45	5.6	0.7	0.3	1875	1996
003Aobl av	121	50		3	48	6.0	1.3	0.0	1882	2003
003Aobl av	118	55		2	40	4.8	0.7	0.0	1885	2006
003Aobl av	110	53		2	37	4.1	0.0	0.9	1860	1981
003Aobl av	119	51		2	52	6.5	0.6	0.1	1869	1990
003Aobl av	122	50		2	40	4.8	0.5	0.3	1879	2000
003Aobl av	118	50		2	48	5.9	0.1	0.9	1868	1989

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003Aobl av	122	46		2	44	5.3	0.2	0.8	1876	1997
003Aobl av	122	52		1	45	5.5	0.0	0.4	1881	2002
003Aobl av	115	50		1	38	4.3	0.0	0.5	1865	1986
003Aobl av	122	44		1	52	6.7	0.0	0.6	1873	1994
003Aobl av	122	54		0	50	6.2	0.0	0.1	1874	1995

Sample (=HalfCh): 003obl av 0 131 1872 2002
Reference (=HalfCh): 003obl av 0 131 1872 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003obl av	131	100	***	1000	100	100.0	100.0	100.0	1872	2002
003obl av	129	54		15	53	7.0	5.0	0.6	1870	2000
003obl av	129	54		15	53	7.0	5.0	0.6	1874	2004
003obl av	125	61	**	8	44	5.4	1.4	1.2	1866	1996
003obl av	119	53		7	31	3.6	1.7	1.1	1860	1990
003obl av	130	35		7	67	10.1	1.0	3.0	1873	2003
003obl av	130	35		7	67	10.1	1.0	3.0	1871	2001
003obl av	114	58		6	31	3.4	1.1	1.3	1855	1985
003obl av	123	52		6	35	4.1	1.7	0.7	1864	1994
003obl av	117	54		5	37	4.2	1.1	0.8	1858	1988
003obl av	122	49		5	42	5.0	1.6	0.7	1863	1993
003obl av	127	61	**	4	45	5.7	0.5	0.8	1868	1998
003obl av	127	61	**	4	45	5.7	0.5	0.8	1876	2006
003obl av	121	53		4	40	4.8	1.0	0.5	1862	1992
003obl av	118	52		4	34	3.8	1.1	0.6	1859	1989
003obl av	128	43		4	46	5.8	0.9	1.3	1875	2005
003obl av	128	43		4	46	5.8	0.9	1.3	1869	1999
003obl av	110	52		2	22	2.4	0.7	0.1	1851	1981
003obl av	112	52		2	20	2.1	0.2	0.8	1853	1983
003obl av	115	50		1	33	3.8	0.3	0.0	1856	1986

Sample (=HalfCh): 004ten av 0 77 1926 2002
Reference (=HalfCh): 003obl av 0 131 1872 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
004ten av	76	67	**	24	8	0.7	4.4	2.8	1927	2003
004ten av	77	63	**	14	4	0.3	2.5	1.8	1918	1994
004ten av	77	59		12	-2	0.2	1.6	2.5	1912	1988
004ten av	74	48		12	-34	3.1	3.2	1.9	1929	2005
004ten av	77	60	*	7	-14	1.2	0.6	1.6	1910	1986
004ten av	77	55		7	-1	0.1	1.0	1.4	1905	1981
004ten av	77	54		5	-20	1.7	0.6	1.3	1923	1999
004ten av	77	63	**	4	-14	1.2	0.0	1.2	1914	1990
004ten av	77	51		4	-14	1.2	0.5	0.9	1906	1982
004ten av	77	50		4	-4	0.3	0.5	0.9	1922	1998
004ten av	73	50		4	-29	2.6	0.8	0.9	1930	2006
004ten av	77	55		3	-18	1.6	0.2	0.9	1924	2000
004ten av	77	55		3	-7	0.6	1.0	0.2	1921	1997
004ten av	77	53		2	-26	2.4	0.6	0.1	1908	1984
004ten av	75	50		1	-17	1.5	0.3	0.1	1928	2004

Sample (=HalfCh): 006pul av 0 134 1869 2002
Reference (=HalfCh): 003obl av 0 131 1872 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
006pul av	113	60	*	12	41	4.8	1.6	2.5	1851	1984
006pul av	119	57		12	36	4.2	2.6	1.8	1857	1990
006pul av	109	56		11	41	4.7	1.9	2.2	1847	1980
006pul av	118	55		11	37	4.2	2.8	1.4	1856	1989
006pul av	117	52		8	27	3.1	2.2	1.0	1855	1988
006pul av	130	57		7	33	3.9	1.4	0.9	1868	2001
006pul av	115	55		6	35	3.9	0.9	1.3	1853	1986
006pul av	111	60	*	4	40	4.5	0.6	0.9	1849	1982
006pul av	130	54		4	39	4.7	0.8	0.6	1873	2006
006pul av	126	53		4	36	4.3	0.7	1.0	1864	1997
006pul av	131	58	*	3	30	3.6	0.9	0.3	1871	2004
006pul av	123	56		3	36	4.3	0.9	0.2	1861	1994
006pul av	129	50		2	29	3.5	0.3	0.5	1867	2000
006pul av	127	55		1	33	3.9	0.4	0.1	1865	1998

Sample	(=HalfCh): 007ten av	0	94	1910	2003
Reference	(=HalfCh): 003obl av	0	131	1872	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
007ten av	94	46		10	-12	1.2	2.9	1.5	1894	1987
007ten av	94	56		7	15	1.5	1.5	1.0	1906	1999
007ten av	94	56		7	40	4.2	1.7	0.7	1908	2001
007ten av	94	55		5	5	0.5	0.9	0.8	1898	1991
007ten av	94	53		5	27	2.7	0.9	1.1	1902	1995
007ten av	94	55		4	4	0.4	0.8	0.6	1895	1988
007ten av	94	53		4	3	0.3	1.6	0.1	1892	1985
007ten av	94	52		4	10	1.0	0.9	0.5	1891	1984
007ten av	93	51		4	26	2.5	1.0	0.6	1910	2003
007ten av	94	51		4	23	2.3	1.3	0.4	1901	1994
007ten av	94	52		3	26	2.6	0.6	0.4	1887	1980
007ten av	94	52		3	-8	0.8	0.9	0.4	1893	1986
007ten av	94	56		2	20	2.0	0.5	0.4	1904	1997
007ten av	94	55		2	13	1.2	0.2	0.5	1900	1993
007ten av	91	53		2	23	2.3	0.2	0.4	1912	2005
007ten av	94	51		2	9	0.9	0.5	0.3	1897	1990
007ten av	94	55		1	15	1.4	0.3	0.2	1889	1982

Sample	(=HalfCh): 008ten av	0	99	1904	2002
Reference	(=HalfCh): 003obl av	0	131	1872	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
008ten av	99	71	***	21	-18	1.8	2.1	3.9	1904	2002
008ten av	99	61	*	13	-12	1.2	1.6	2.5	1896	1994
008ten av	99	62	**	12	-20	2.0	2.0	2.0	1887	1985
008ten av	98	32		12	-39	4.1	3.2	4.2	1905	2003
008ten av	97	60	*	7	-28	2.8	0.6	1.9	1906	2004
008ten av	99	58		7	-14	1.4	0.5	1.9	1902	2000
008ten av	99	55		7	-27	2.7	0.7	1.8	1889	1987
008ten av	99	57		5	-32	3.4	0.7	1.1	1883	1981
008ten av	99	54		5	-26	2.6	1.3	0.6	1890	1988
008ten av	95	61	*	3	-32	3.3	0.8	0.3	1908	2006
008ten av	99	60	*	3	-24	2.5	0.2	0.7	1894	1992
008ten av	99	58		3	-19	1.9	0.1	0.8	1900	1998
008ten av	99	52		3	-36	3.7	1.0	0.1	1885	1983

008ten av	99	60	*	2	-28	2.9	0.7	0.1	1893	1991
008ten av	99	52		2	-22	2.2	0.3	0.5	1898	1996

Sample (=HalfCh): 009ten av 0 74 1929 2002
Reference (=HalfCh): 003obl av 0 131 1872 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
009ten av	74	61	*	12	32	2.9	2.0	2.0	1919	1992
009ten av	74	64	**	8	22	1.9	1.1	1.3	1915	1988
009ten av	74	50		8	23	2.0	1.9	1.1	1921	1994
009ten av	74	53		6	32	2.9	1.4	0.8	1926	1999
009ten av	70	52		6	6	0.5	1.6	1.0	1933	2006
009ten av	74	50		5	15	1.3	1.0	1.1	1924	1997
009ten av	74	56		4	20	1.7	1.2	0.1	1917	1990
009ten av	74	56		3	30	2.6	0.7	0.3	1920	1993
009ten av	74	51		3	31	2.7	0.7	0.7	1912	1985
009ten av	74	50		3	21	1.8	0.8	0.5	1923	1996
009ten av	74	58		2	21	1.8	0.3	0.4	1911	1984
009ten av	74	54		2	21	1.8	0.1	0.7	1925	1998
009ten av	71	54		2	4	0.4	0.1	0.8	1932	2005
009ten av	72	52		2	2	0.2	0.2	0.6	1931	2004
009ten av	74	52		2	17	1.4	0.4	0.4	1910	1983
009ten av	73	56		1	1	0.1	0.0	0.3	1930	2003
009ten av	74	51		1	26	2.2	0.3	0.3	1927	2000
009ten av	74	51		1	15	1.3	0.4	0.1	1928	2001

Sample (=HalfCh): c04obl av 0 155 1848 2002
Reference (=HalfCh): 003obl av 0 131 1872 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c04obl av	126	52		15	33	3.9	3.4	2.5	1843	1997
c04obl av	128	50		11	13	1.5	2.8	1.6	1845	1999
c04obl av	116	51		8	20	2.2	1.7	1.7	1833	1987
c04obl av	125	59	*	7	34	4.1	1.6	0.7	1842	1996
c04obl av	123	50		7	21	2.3	1.7	1.0	1840	1994
c04obl av	121	54		5	20	2.3	1.4	0.6	1838	1992
c04obl av	113	54		4	40	4.6	0.8	0.7	1830	1984
c04obl av	131	51		4	19	2.2	1.4	0.3	1848	2002
c04obl av	110	56		3	40	4.5	1.1	0.0	1827	1981
c04obl av	117	56		3	22	2.5	0.6	0.5	1834	1988
c04obl av	124	53		3	28	3.2	0.6	0.5	1841	1995
c04obl av	114	53		3	35	4.0	0.6	0.8	1831	1985
c04obl av	131	51		3	20	2.3	0.8	0.4	1849	2003
c04obl av	111	54		2	38	4.3	0.7	0.1	1828	1982
c04obl av	109	49		2	44	5.1	0.7	0.3	1826	1980
c04obl av	131	52		1	20	2.3	0.2	0.2	1850	2004

Sample (=HalfCh): c06pul av 0 130 1873 2002
Reference (=HalfCh): 003obl av 0 131 1872 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c06pul av	122	60	*	19	24	2.7	2.9	3.6	1864	1993
c06pul av	129	58	*	14	18	2.1	1.7	3.2	1871	2000
c06pul av	128	60	*	12	12	1.4	1.7	2.4	1875	2004

```
c06pul av   127  56        11   10   1.1   1.6   2.5   1869   1998
c06pul av   128  47        10    2   0.2   1.7   2.5   1870   1999
c06pul av   111  55         8   12   1.3   2.0   1.3   1853   1982
c06pul av   120  57         6   23   2.5   0.8   1.5   1862   1991
c06pul av   130  51         4   10   1.2   0.8   0.7   1873   2002
c06pul av   112  50         4    7   0.7   0.9   0.7   1854   1983
c06pul av   118  57         3   12   1.4   0.0   1.0   1860   1989
c06pul av   116  56         3   10   1.1   0.0   1.2   1858   1987
c06pul av   114  52         3   12   1.2   0.7   0.8   1856   1985
c06pul av   124  50         2    3   0.4   0.5   0.3   1866   1995
-----------------------------------------------------------------

Sample    (=HalfCh): c07obl av                      0      114  1889  2002
Reference (=HalfCh): 003obl av                      0      131  1872  2002

  Sample    OVL Glk GSL    CDI  %CC    TV  TVBP  TVH   DateL  DateR
c07obl av   111  49        10   16   1.7   2.0   2.0   1892   2005
c07obl av   114  51         8   38   4.3   1.9   1.3   1888   2001
c07obl av   114  52         7   35   4.0   1.3   1.3   1886   1999
c07obl av   114  56         6   21   2.2   1.3   0.9   1889   2002
c07obl av   114  52         6   39   4.5   1.2   1.1   1887   2000
c07obl av   114  53         5   -7   0.8   0.9   1.1   1874   1987
c07obl av   113  51         5   19   2.1   1.0   1.0   1890   2003
c07obl av   114  55         4   35   4.0   0.3   1.3   1885   1998
c07obl av   114  54         4   -2   0.2   0.9   0.5   1877   1990
c07obl av   114  53         4   25   2.7   0.4   1.2   1883   1996
c07obl av   112  55         3  -10   1.1   0.2   0.9   1870   1983
c07obl av   114  54         3   11   1.2   0.6   0.6   1880   1993
c07obl av   114  52         3   18   1.9   0.3   0.7   1881   1994
c07obl av   110  50         3   -4   0.5   0.4   0.8   1868   1981
c07obl av   114  51         2   -9   1.0   0.5   0.3   1876   1989
c07obl av   114  50         2   20   2.1   0.7   0.0   1882   1995
c07obl av   114  50         1   -1   0.1   0.4   0.1   1878   1991
-----------------------------------------------------------------

Sample    (=HalfCh): c08ten av                      0       93  1910  2002
Reference (=HalfCh): 003obl av                      0      131  1872  2002

  Sample    OVL Glk GSL    CDI  %CC    TV  TVBP  TVH   DateL  DateR
c08ten av    93  43        12  -14   1.4   3.3   2.5   1895   1987
c08ten av    93  62 *      10    5   0.5   1.7   1.7   1896   1988
c08ten av    93  56        10   40   4.1   2.2   1.4   1909   2001
c08ten av    93  59 *       9   21   2.1   1.3   1.6   1905   1997
c08ten av    93  63 **      8   17   1.7   0.9   1.5   1890   1982
c08ten av    93  52         8   14   1.3   2.3   0.8   1907   1999
c08ten av    93  55         6   27   2.7   0.9   1.3   1888   1980
c08ten av    93  52         5   24   2.3   1.4   0.7   1902   1994
c08ten av    90  56         4   23   2.3   0.3   1.0   1913   2005
c08ten av    93  56         3    9   0.8   0.0   1.0   1899   1991
c08ten av    93  52         3    0   0.0   1.3   0.0   1893   1985
c08ten av    93  54         2   16   1.5   0.1   0.8   1901   1993
c08ten av    93  52         2  -10   0.9   0.7   0.1   1894   1986
c08ten av    93  52         1    8   0.8   0.1   0.3   1892   1984
-----------------------------------------------------------------

Sample    (=HalfCh): c12ten av                      0      138  1867  2004
Reference (=HalfCh): 004ten av                      0       77  1926  2002
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Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c12ten av	77	50		11	19	1.7	2.9	1.7	1866	2003
c12ten av	75	57		9	15	1.3	1.7	1.4	1863	2000
c12ten av	76	52		8	-4	0.3	1.7	1.5	1864	2001
c12ten av	67	55		7	17	1.4	1.9	0.9	1855	1992
c12ten av	64	56		6	8	0.7	1.0	1.2	1852	1989
c12ten av	66	62	*	4	3	0.3	0.1	1.3	1854	1991
c12ten av	73	57		3	16	1.4	0.1	0.9	1861	1998
c12ten av	70	64	**	2	22	1.8	0.3	0.3	1858	1995
c12ten av	56	56		2	4	0.3	0.4	0.3	1844	1981
c12ten av	57	55		2	9	0.6	0.0	0.6	1845	1982
c12ten av	77	53		2	6	0.5	0.3	0.4	1867	2004
c12ten av	72	56		1	9	0.8	0.0	0.3	1860	1997
c12ten av	62	56		1	-3	0.2	0.5	0.0	1850	1987
c12ten av	61	55		1	1	0.1	0.5	0.0	1849	1986
c12ten av	60	53		1	14	1.1	0.3	0.2	1848	1985
c12ten av	69	50		1	8	0.6	0.2	0.2	1857	1994
c12ten av	77	53		0	-1	0.1	0.0	0.1	1869	2006

Sample (=HalfCh): 003Aobl av 0 122 1881 2002
Reference (=HalfCh): 004ten av 0 77 1926 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003Aobl av	57	52		9	20	1.5	2.1	2.0	1861	1982
003Aobl av	77	56		8	5	0.4	1.5	1.4	1882	2003
003Aobl av	64	60	*	6	4	0.3	1.4	0.8	1868	1989
003Aobl av	65	60		6	17	1.4	1.1	1.1	1869	1990
003Aobl av	77	57		6	2	0.2	1.2	0.8	1883	2004
003Aobl av	55	54		4	8	0.6	1.0	1.0	1859	1980
003Aobl av	72	52		3	-26	2.2	0.0	1.0	1876	1997
003Aobl av	56	58		2	21	1.6	0.4	0.5	1860	1981
003Aobl av	69	57		2	-4	0.4	0.1	0.8	1873	1994
003Aobl av	77	53		2	-14	1.2	0.3	0.4	1881	2002
003Aobl av	77	53		2	-9	0.8	0.6	0.2	1884	2005
003Aobl av	73	52		2	-33	2.9	0.2	0.6	1877	1998
003Aobl av	63	50		2	-18	1.4	0.1	0.7	1867	1988
003Aobl av	74	50		2	-36	3.3	0.3	0.4	1878	1999
003Aobl av	70	54		1	-12	1.0	0.3	0.1	1874	1995
003Aobl av	58	53		1	7	0.6	0.1	0.1	1862	1983

Sample (=HalfCh): 003obl av 0 131 1872 2002
Reference (=HalfCh): 004ten av 0 77 1926 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003obl av	76	67	**	24	8	0.7	4.4	2.8	1871	2001
003obl av	72	59		14	-14	1.2	2.5	2.3	1867	1997
003obl av	66	63	*	13	4	0.3	2.2	2.1	1861	1991
003obl av	74	48		12	-34	3.1	3.2	1.9	1869	1999
003obl av	62	56		11	2	0.1	2.1	2.3	1857	1987
003obl av	69	53		7	-5	0.4	1.5	1.2	1864	1994
003obl av	77	54		5	-20	1.7	0.6	1.3	1875	2005
003obl av	73	50		4	-29	2.6	0.8	0.9	1868	1998
003obl av	77	50		4	-4	0.3	0.5	0.9	1876	2006
003obl av	77	55		3	-18	1.6	0.2	0.9	1874	2004

003obl av	70	55		3	-21	1.8	0.7	0.2	1865	1995
003obl av	55	55		3	20	1.5	0.4	0.9	1850	1980
003obl av	67	52		3	-1	0.1	0.7	0.6	1862	1992
003obl av	60	59		2	-19	1.5	0.1	0.6	1855	1985
003obl av	56	50		2	9	0.6	0.7	0.1	1851	1981
003obl av	58	56		1	-8	0.6	0.3	0.0	1853	1983
003obl av	75	50		1	-17	1.5	0.3	0.1	1870	2000

Sample (=HalfCh): 004ten av 0 77 1926 2002
Reference (=HalfCh): 004ten av 0 77 1926 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
004ten av	77	100	***	1000	100	100.0	100.0	100.0	1926	2002
004ten av	75	51		10	16	1.4	3.5	0.5	1924	2000
004ten av	75	51		10	16	1.4	3.5	0.5	1928	2004
004ten av	76	36		10	33	3.0	1.8	3.6	1927	2003
004ten av	76	36		10	33	3.0	1.8	3.6	1925	2001
004ten av	64	67	**	9	24	1.9	1.0	1.8	1913	1989
004ten av	58	60		9	-2	0.1	1.5	1.9	1907	1983
004ten av	62	61	*	8	24	1.9	1.5	1.5	1911	1987
004ten av	71	57		6	8	0.6	1.6	0.8	1920	1996
004ten av	55	59		4	2	0.1	0.7	0.7	1904	1980
004ten av	60	51		3	-15	1.2	1.1	0.2	1909	1985
004ten av	73	50		2	1	0.1	0.4	0.4	1922	1998
004ten av	73	50		2	1	0.1	0.4	0.4	1930	2006
004ten av	68	63	*	1	-6	0.5	0.3	0.1	1917	1993
004ten av	56	55		1	-3	0.2	0.4	0.2	1905	1981

Sample (=HalfCh): 006pul av 0 134 1869 2002
Reference (=HalfCh): 004ten av 0 77 1926 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
006pul av	71	70	***	21	25	2.1	3.0	3.2	1863	1996
006pul av	75	60	*	12	4	0.3	2.2	1.8	1867	2000
006pul av	60	58		12	-17	1.3	2.7	2.0	1852	1985
006pul av	77	53		9	21	1.8	1.3	2.1	1872	2005
006pul av	56	60		6	-2	0.2	0.9	1.2	1848	1981
006pul av	73	55		6	1	0.1	1.7	0.4	1865	1998
006pul av	68	53		6	32	2.7	1.9	0.6	1860	1993
006pul av	67	51		5	17	1.4	0.9	1.1	1859	1992
006pul av	69	58		4	29	2.5	0.6	0.8	1861	1994
006pul av	58	53		4	-27	2.1	1.4	0.2	1850	1983
006pul av	77	57		3	22	2.0	0.6	0.6	1873	2006
006pul av	62	56		3	-40	3.4	0.9	0.1	1854	1987
006pul av	63	52		2	-37	3.2	0.8	0.0	1855	1988
006pul av	77	56		1	-7	0.6	0.1	0.4	1870	2003
006pul av	77	52		1	-10	0.8	0.3	0.1	1869	2002

Sample (=HalfCh): 007ten av 0 94 1910 2003
Reference (=HalfCh): 004ten av 0 77 1926 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
007ten av	71	64	*	19	0	0.0	4.1	2.0	1903	1996
007ten av	73	48		12	-21	1.8	3.0	2.1	1905	1998

007ten av	65	69	**	7	17	1.4	0.8	1.4	1897	1990
007ten av	77	55		4	29	2.6	0.8	0.7	1910	2003
007ten av	60	54		4	12	0.9	0.4	1.1	1892	1985
007ten av	67	54		4	2	0.2	0.7	1.0	1899	1992
007ten av	77	53		4	30	2.8	0.6	0.7	1909	2002
007ten av	68	52		4	-9	0.8	1.3	0.2	1900	1993
007ten av	75	60	*	3	10	0.9	0.6	0.6	1907	2000
007ten av	69	52		3	-18	1.5	1.4	0.0	1901	1994
007ten av	62	56		2	22	1.8	0.3	0.3	1894	1987
007ten av	59	54		2	4	0.3	0.4	0.4	1891	1984
007ten av	58	60		1	-2	0.1	0.1	0.2	1890	1983
007ten av	77	57		1	7	0.6	0.3	0.2	1912	2005
007ten av	56	53		1	-8	0.6	0.3	0.3	1888	1981

Sample (=HalfCh): 008ten av 0 99 1904 2002
Reference (=HalfCh): 004ten av 0 77 1926 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
008ten av	68	61	*	17	25	2.1	3.9	2.2	1895	1993
008ten av	74	65	**	15	26	2.3	2.3	2.3	1901	1999
008ten av	70	50		9	-1	0.1	2.0	1.6	1897	1995
008ten av	77	55		7	10	0.9	0.9	1.8	1908	2006
008ten av	66	56		4	6	0.5	1.5	0.1	1893	1991
008ten av	64	50		4	21	1.7	0.8	0.7	1891	1989
008ten av	61	53		3	42	3.5	0.9	0.5	1888	1986
008ten av	76	58		2	10	0.9	0.1	0.6	1903	2001
008ten av	55	52		2	2	0.2	0.4	0.5	1882	1980
008ten av	77	51		2	-5	0.5	0.6	0.4	1906	2004
008ten av	77	51		2	-8	0.7	0.5	0.4	1905	2003
008ten av	62	58		1	29	2.4	0.0	0.4	1889	1987
008ten av	59	58		1	29	2.3	0.4	0.0	1886	1984
008ten av	72	57		1	0	0.0	0.4	0.1	1899	1997

Sample (=HalfCh): 009ten av 0 74 1929 2002
Reference (=HalfCh): 004ten av 0 77 1926 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
009ten av	74	58		6	-13	1.1	0.7	1.2	1929	2002
009ten av	62	59		5	-2	0.1	0.7	1.0	1914	1987
009ten av	74	58		5	-14	1.2	0.5	1.3	1927	2000
009ten av	57	56		4	-12	0.9	1.0	0.7	1909	1982
009ten av	68	55		4	-17	1.4	1.0	0.5	1920	1993
009ten av	65	55		4	4	0.3	1.2	0.5	1917	1990
009ten av	70	54		4	-15	1.3	0.9	0.7	1922	1995
009ten av	73	50		4	-26	2.3	0.9	0.7	1925	1998
009ten av	64	52		3	4	0.3	0.3	1.1	1916	1989
009ten av	67	52		3	-10	0.8	0.8	0.3	1919	1992
009ten av	56	61	*	2	-16	1.2	0.5	0.1	1908	1981
009ten av	71	57		2	-5	0.4	0.7	0.1	1932	2005
009ten av	71	54		2	-20	1.7	0.8	0.0	1923	1996
009ten av	66	52		2	0	0.0	0.2	0.4	1918	1991
009ten av	60	54		1	-8	0.6	0.4	0.2	1912	1985
009ten av	58	54		1	-8	0.6	0.2	0.3	1910	1983
009ten av	74	52		1	-21	1.9	0.0	0.5	1926	1999

```
Sample    (=HalfCh): c04obl av                        0      155  1848  2002
Reference (=HalfCh): 004ten av                        0       77  1926  2002

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
c04obl av    77  59        11    6   0.5   1.8   1.8   1848   2002
c04obl av    71  57        10   11   1.0   2.1   1.6   1842   1996
c04obl av    77  57         8   18   1.6   1.7   1.1   1852   2006
c04obl av    77  53         8   28   2.5   2.0   0.9   1851   2005
c04obl av    55  59         7  -21   1.6   1.3   1.2   1826   1980
c04obl av    77  51         7   12   1.1   1.9   0.8   1850   2004
c04obl av    74  58         6    6   0.5   1.3   1.0   1845   1999
c04obl av    59  58         6   -3   0.3   1.3   1.1   1830   1984
c04obl av    63  51         6   -8   0.6   1.4   1.4   1834   1988
c04obl av    66  55         5   -3   0.2   1.2   0.7   1837   1991
c04obl av    64  56         4  -10   0.8   1.0   0.6   1835   1989
c04obl av    61  53         4  -16   1.2   1.2   0.4   1832   1986
c04obl av    67  51         4   -6   0.5   0.7   0.9   1838   1992
c04obl av    68  55         2   -9   0.8   0.4   0.2   1839   1993
c04obl av    72  54         2    2   0.2   0.5   0.2   1843   1997
c04obl av    65  51         2   -8   0.6   0.4   0.3   1836   1990
c04obl av    58  54         1   -9   0.7   0.2   0.2   1829   1983
----------------------------------------------------------------------

Sample    (=HalfCh): c06pul av                        0      130  1873  2002
Reference (=HalfCh): 004ten av                        0       77  1926  2002

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
c06pul av    69  41        11  -21   1.7   3.0   2.7   1865   1994
c06pul av    73  46        10  -20   1.7   2.8   1.6   1869   1998
c06pul av    59  55         9   25   2.0   1.6   2.1   1855   1984
c06pul av    65  61 *       8   10   0.8   1.6   1.0   1861   1990
c06pul av    77  57         8    8   0.7   1.7   1.3   1874   2003
c06pul av    68  55         8    2   0.2   1.4   1.8   1864   1993
c06pul av    57  59         7   33   2.6   1.1   1.5   1853   1982
c06pul av    72  51         7   12   1.0   1.2   1.8   1868   1997
c06pul av    76  53         6   -8   0.7   1.0   1.2   1872   2001
c06pul av    61  53         5   -9   0.7   1.3   1.0   1857   1986
c06pul av    70  55         4    4   0.3   0.1   1.3   1866   1995
c06pul av    74  55         2   -3   0.3   0.5   0.1   1870   1999
c06pul av    77  53         2    6   0.5   0.5   0.2   1877   2006
c06pul av    67  50         2   -2   0.1   0.2   0.8   1863   1992
c06pul av    60  56         1    7   0.5   0.0   0.4   1856   1985
c06pul av    77  53         1    6   0.5   0.1   0.2   1876   2005
c06pul av    55  50         1   10   0.7   0.5   0.2   1851   1980
c06pul av    63  55         0   -6   0.5   0.0   0.0   1859   1988
----------------------------------------------------------------------

Sample    (=HalfCh): c07obl av                        0      114  1889  2002
Reference (=HalfCh): 004ten av                        0       77  1926  2002

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
c07obl av    57  61 *      14   36   2.9   2.8   2.3   1869   1982
c07obl av    77  59        13   -3   0.3   2.3   2.2   1893   2006
c07obl av    77  58        13   16   1.4   2.4   2.2   1889   2002
c07obl av    70  55        12    1   0.1   2.4   2.2   1882   1995
c07obl av    77  50        10  -13   1.2   2.5   1.5   1891   2004
```

c07obl av	64	56		9	25	2.0	1.8	1.8	1876	1989
c07obl av	72	51		4	-6	0.5	1.1	0.5	1884	1997
c07obl av	75	55		3	18	1.5	0.2	0.7	1887	2000
c07obl av	66	55		3	-5	0.4	1.1	0.0	1878	1991
c07obl av	58	53		3	17	1.3	0.6	0.8	1870	1983
c07obl av	62	51		3	40	3.4	0.5	0.7	1874	1987
c07obl av	68	61	*	2	-3	0.3	0.1	0.5	1880	1993
c07obl av	73	54		2	2	0.2	0.5	0.2	1885	1998
c07obl av	60	51		2	36	2.9	0.3	0.4	1872	1985
c07obl av	55	56		1	23	1.7	0.3	0.1	1867	1980
c07obl av	61	50		1	36	3.0	0.2	0.1	1873	1986

Sample (=HalfCh): c08ten av 0 93 1910 2002
Reference (=HalfCh): 004ten av 0 77 1926 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c08ten av	71	65	**	22	3	0.2	4.6	2.4	1904	1996
c08ten av	73	46		11	-21	1.8	2.8	1.9	1906	1998
c08ten av	65	67	**	7	17	1.4	0.7	1.4	1898	1990
c08ten av	60	56		6	12	0.9	0.8	1.5	1893	1985
c08ten av	77	51		5	32	2.9	0.9	0.9	1910	2002
c08ten av	77	57		4	30	2.7	0.7	0.6	1911	2003
c08ten av	69	54		4	-18	1.5	1.5	0.0	1902	1994
c08ten av	67	52		4	1	0.1	0.6	1.0	1900	1992
c08ten av	68	50		3	-12	0.9	1.0	0.4	1901	1993
c08ten av	58	58		2	-2	0.2	0.3	0.4	1891	1983
c08ten av	59	52		2	1	0.1	0.2	0.8	1892	1984
c08ten av	75	59		1	8	0.7	0.2	0.1	1908	2000
c08ten av	77	58		1	8	0.7	0.1	0.4	1913	2005
c08ten av	56	55		1	-2	0.2	0.3	0.2	1889	1981
c08ten av	62	54		1	19	1.5	0.2	0.1	1895	1987

Sample (=HalfCh): c12ten av 0 138 1867 2004
Reference (=HalfCh): 006pul av 0 134 1869 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c12ten av	134	55		12	35	4.3	2.1	2.3	1867	2004
c12ten av	132	56		10	39	4.8	1.7	1.9	1863	2000
c12ten av	133	55		7	32	3.9	1.1	1.3	1864	2001
c12ten av	118	54		6	7	0.7	0.9	1.5	1849	1986
c12ten av	123	51		6	14	1.6	1.5	0.9	1854	1991
c12ten av	126	51		6	16	1.9	1.1	1.2	1857	1994
c12ten av	114	57		3	26	2.8	0.6	0.4	1845	1982
c12ten av	119	52		3	8	0.8	0.8	0.3	1850	1987
c12ten av	120	52		2	5	0.5	0.0	0.7	1851	1988
c12ten av	134	51		2	32	3.9	0.7	0.1	1866	2003
c12ten av	134	51		2	20	2.3	0.7	0.0	1869	2006
c12ten av	115	50		2	21	2.2	0.8	0.1	1846	1983
c12ten av	122	50		2	11	1.2	0.5	0.2	1853	1990
c12ten av	131	53		1	32	3.8	0.2	0.2	1862	1999
c12ten av	128	52		1	22	2.6	0.1	0.5	1859	1996
c12ten av	129	50		1	30	3.5	0.1	0.2	1860	1997

Sample (=HalfCh): 003Aobl av 0 122 1881 2002

Reference	(=HalfCh):	006pul av	0	134	1869	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003Aobl av	122	60	*	11	50	6.4	2.0	1.8	1870	1991
003Aobl av	122	56		9	39	4.6	1.9	1.2	1874	1995
003Aobl av	122	51		8	51	6.5	1.4	1.8	1879	2000
003Aobl av	114	57		7	32	3.6	1.4	1.2	1861	1982
003Aobl av	121	59	*	6	53	6.8	0.4	1.5	1868	1989
003Aobl av	117	54		6	39	4.6	1.4	1.1	1864	1985
003Aobl av	122	52		5	50	6.2	1.6	0.1	1869	1990
003Aobl av	122	52		5	36	4.2	0.5	1.4	1873	1994
003Aobl av	122	46		5	43	5.2	1.3	0.7	1876	1997
003Aobl av	116	55		4	34	3.8	0.8	0.7	1863	1984
003Aobl av	122	54		3	50	6.4	0.6	0.4	1877	1998
003Aobl av	118	53		3	35	4.1	1.2	0.0	1885	2006
003Aobl av	119	52		3	42	5.0	0.3	0.8	1866	1987
003Aobl av	120	49		3	45	5.5	0.6	0.7	1867	1988
003Aobl av	122	54		2	50	6.3	0.5	0.1	1878	1999
003Aobl av	122	53		2	43	5.2	0.4	0.5	1880	2001
003Aobl av	112	53		2	34	3.8	0.4	0.6	1859	1980
003Aobl av	121	53		0	36	4.2	0.0	0.1	1882	2003

Sample	(=HalfCh):	003obl av	0	131	1872	2002
Reference	(=HalfCh):	006pul av	0	134	1869	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003obl av	113	58	*	9	51	6.2	1.8	1.7	1851	1981
003obl av	116	56		9	58	7.6	1.3	2.0	1854	1984
003obl av	120	50		9	56	7.3	1.8	1.7	1858	1988
003obl av	130	57		7	33	3.9	1.4	0.9	1873	2003
003obl av	128	51		5	33	3.9	1.0	1.0	1866	1996
003obl av	117	50		5	49	6.0	1.1	1.2	1855	1985
003obl av	130	54		4	39	4.7	0.8	0.6	1868	1998
003obl av	122	52		4	38	4.5	0.8	0.9	1860	1990
003obl av	131	58	*	3	30	3.6	0.9	0.3	1870	2000
003obl av	118	57		3	50	6.1	1.0	0.2	1856	1986
003obl av	129	50		3	37	4.6	1.0	0.0	1867	1997
003obl av	114	57		2	50	6.2	0.4	0.5	1852	1982
003obl av	123	52		2	37	4.4	0.5	0.4	1861	1991
003obl av	129	50		2	29	3.5	0.3	0.5	1874	2004
003obl av	125	50		2	33	3.9	0.5	0.4	1863	1993
003obl av	115	46		2	53	6.7	0.4	0.8	1853	1983
003obl av	127	55		1	33	3.9	0.4	0.1	1876	2006
003obl av	126	51		1	30	3.5	0.2	0.1	1864	1994
003obl av	119	48		1	52	6.6	0.0	0.5	1857	1987
003obl av	121	46		1	45	5.5	0.4	0.2	1859	1989

Sample	(=HalfCh):	004ten av	0	77	1926	2002
Reference	(=HalfCh):	006pul av	0	134	1869	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
004ten av	77	63	*	15	7	0.6	3.0	1.9	1913	1989
004ten av	77	61	*	14	3	0.3	1.8	2.7	1906	1982
004ten av	77	61	*	13	8	0.7	1.9	2.3	1917	1993
004ten av	77	43		13	-25	2.3	3.5	2.8	1911	1987

004ten av	75	60	*	12	4	0.3	2.2	1.8	1928	2004
004ten av	77	53		9	21	1.8	1.3	2.1	1923	1999
004ten av	73	55		6	1	0.1	1.7	0.4	1930	2006
004ten av	77	53		6	-3	0.3	0.5	1.9	1907	1983
004ten av	77	61	*	5	-10	0.9	1.2	0.4	1915	1991
004ten av	77	56		4	-8	0.7	0.3	1.2	1904	1980
004ten av	77	53		4	-7	0.6	1.0	0.5	1912	1988
004ten av	77	52		4	30	2.7	0.5	1.1	1921	1997
004ten av	77	52		4	2	0.2	0.2	1.4	1908	1984
004ten av	77	57		3	22	2.0	0.6	0.6	1922	1998
004ten av	77	55		3	12	1.0	0.7	0.4	1919	1995
004ten av	77	52		3	-18	1.6	0.2	0.8	1910	1986
004ten av	77	52		3	-7	0.6	1.1	0.1	1909	1985
004ten av	77	56		1	-7	0.6	0.1	0.4	1925	2001
004ten av	77	52		1	-10	0.8	0.3	0.1	1926	2002

Sample (=HalfCh): 006pul av 0 134 1869 2002
Reference (=HalfCh): 006pul av 0 134 1869 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
006pul av	134	100	***	1000	100	100.0	100.0	100.0	1869	2002
006pul av	132	49		13	67	10.2	4.5	0.7	1867	2000
006pul av	132	49		13	67	10.2	4.5	0.7	1871	2004
006pul av	133	41		12	77	13.8	1.5	4.2	1870	2003
006pul av	133	41		12	77	13.8	1.5	4.2	1868	2001
006pul av	116	56		11	35	4.0	2.3	1.9	1851	1984
006pul av	130	55		9	55	7.5	1.7	1.7	1865	1998
006pul av	130	55		9	55	7.5	1.7	1.7	1873	2006
006pul av	131	43		8	59	8.4	1.7	2.4	1872	2005
006pul av	131	43		8	59	8.4	1.7	2.4	1866	1999
006pul av	124	51		6	27	3.1	1.2	1.3	1859	1992
006pul av	112	60	*	5	33	3.6	1.1	0.7	1847	1980
006pul av	117	54		5	36	4.1	0.8	1.0	1852	1985
006pul av	118	55		3	37	4.4	0.9	0.2	1853	1986
006pul av	129	50		3	49	6.3	0.6	0.4	1864	1997
006pul av	126	53		2	35	4.2	0.8	0.1	1861	1994
006pul av	113	53		2	29	3.1	0.6	0.4	1848	1981
006pul av	121	50		2	38	4.4	0.5	0.5	1856	1989
006pul av	128	53		1	43	5.3	0.5	0.1	1863	1996
006pul av	122	53		1	33	3.8	0.1	0.4	1857	1990
006pul av	115	51		1	32	3.6	0.4	0.0	1850	1983

Sample (=HalfCh): 007ten av 0 94 1910 2003
Reference (=HalfCh): 006pul av 0 134 1869 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
007ten av	94	58		19	3	0.3	3.6	3.1	1909	2002
007ten av	94	60	*	12	40	4.2	2.3	1.7	1898	1991
007ten av	94	45		11	-2	0.2	3.3	1.7	1907	2000
007ten av	94	53		7	42	4.4	1.8	0.9	1904	1997
007ten av	94	58		6	35	3.6	1.7	0.5	1890	1983
007ten av	94	58		6	34	3.5	1.8	0.4	1905	1998
007ten av	92	58		4	-14	1.4	0.7	0.5	1911	2004
007ten av	94	53		4	34	3.5	0.8	0.8	1894	1987
007ten av	94	55		3	33	3.4	0.8	0.4	1896	1989

007ten av	94	55		2	31	3.2	0.3	0.3	1901	1994
007ten av	94	55		2	33	3.4	0.2	0.4	1899	1992
007ten av	94	54		1	39	4.1	0.3	0.2	1903	1996
007ten av	94	54		1	34	3.4	0.4	0.1	1893	1986

Sample	(=HalfCh): 008ten av	0	99	1904	2002
Reference	(=HalfCh): 006pul av	0	134	1869	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
008ten av	99	55		10	-10	1.0	1.6	1.9	1902	2000
008ten av	96	59	*	9	-2	0.2	1.7	1.3	1907	2005
008ten av	99	53		8	-13	1.3	1.4	1.5	1898	1996
008ten av	99	55		5	-35	3.6	1.0	0.9	1890	1988
008ten av	99	55		5	-19	1.9	1.3	0.7	1885	1983
008ten av	99	52		5	-15	1.4	0.6	1.2	1899	1997
008ten av	97	51		5	-15	1.5	1.0	0.9	1906	2004
008ten av	99	55		4	-14	1.4	0.3	0.9	1883	1981
008ten av	99	51		4	-34	3.5	0.9	0.7	1892	1990
008ten av	99	57		3	-33	3.4	0.4	0.6	1888	1986
008ten av	99	55		3	-22	2.2	0.9	0.3	1894	1992
008ten av	99	51		3	-15	1.5	0.5	0.6	1882	1980
008ten av	99	57		2	-13	1.3	0.1	0.5	1897	1995
008ten av	95	51		2	-9	0.9	0.4	0.4	1908	2006
008ten av	98	53		1	-18	1.7	0.2	0.2	1905	2003
008ten av	99	51		1	-19	1.9	0.0	0.3	1895	1993

Sample	(=HalfCh): 009ten av	0	74	1929	2002
Reference	(=HalfCh): 006pul av	0	134	1869	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
009ten av	74	62	*	21	28	2.5	3.2	3.6	1909	1982
009ten av	74	60	*	13	-19	1.6	2.6	1.8	1916	1989
009ten av	74	44		12	-38	3.5	2.6	2.7	1914	1987
009ten av	70	63	*	11	-7	0.6	1.7	1.9	1933	2006
009ten av	73	43		10	-29	2.6	2.8	1.9	1930	2003
009ten av	74	53		8	18	1.5	1.9	1.2	1928	2001
009ten av	74	59		6	4	0.3	0.8	1.1	1921	1994
009ten av	74	51		6	20	1.8	0.7	1.5	1908	1981
009ten av	74	51		6	15	1.3	2.0	0.4	1907	1980
009ten av	74	56		5	25	2.2	1.0	0.8	1927	2000
009ten av	74	55		4	20	1.7	0.6	0.9	1923	1996
009ten av	74	51		4	-28	2.5	1.0	0.6	1915	1988
009ten av	74	53		3	-6	0.5	0.5	0.5	1929	2002
009ten av	74	51		3	-17	1.5	0.4	0.6	1919	1992
009ten av	74	52		2	-27	2.4	0.9	0.1	1913	1986
009ten av	74	51		2	29	2.6	0.1	0.5	1925	1998
009ten av	74	52		1	-21	1.8	0.4	0.1	1918	1991
009ten av	74	51		1	12	1.0	0.1	0.5	1922	1995

Sample	(=HalfCh): c04obl av	0	155	1848	2002
Reference	(=HalfCh): 006pul av	0	134	1869	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c04obl av	133	59	*	11	45	5.8	1.3	2.6	1847	2001

c04obl av	132	52		11	39	4.8	1.9	2.3	1846	2000
c04obl av	129	59	*	9	39	4.8	2.2	1.0	1843	1997
c04obl av	118	56		7	33	3.7	1.9	0.9	1832	1986
c04obl av	122	56		6	30	3.4	1.2	1.0	1836	1990
c04obl av	134	52		5	38	4.7	0.8	1.0	1849	2003
c04obl av	112	54		4	24	2.6	1.1	0.4	1826	1980
c04obl av	117	53		4	35	4.0	1.1	0.6	1831	1985
c04obl av	115	58	*	3	31	3.4	0.8	0.4	1829	1983
c04obl av	125	55		2	29	3.4	0.3	0.3	1839	1993
c04obl av	134	51		2	43	5.5	0.7	0.1	1848	2002

Sample	(=HalfCh): c06pul av	0	130	1873	2002
Reference	(=HalfCh): 006pul av	0	134	1869	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c06pul av	127	63	**	17	37	4.4	2.6	2.8	1876	2005
c06pul av	119	62	**	13	24	2.7	2.5	1.7	1858	1987
c06pul av	128	44		11	20	2.3	2.4	2.6	1875	2004
c06pul av	126	58	*	10	17	1.9	1.9	1.6	1865	1994
c06pul av	117	44		10	13	1.4	2.5	2.5	1856	1985
c06pul av	130	54		6	19	2.2	1.5	0.8	1870	1999
c06pul av	118	52		6	24	2.6	1.2	1.1	1857	1986
c06pul av	116	50		5	19	2.0	0.2	1.9	1855	1984
c06pul av	113	50		4	2	0.2	0.8	0.7	1852	1981
c06pul av	121	56		3	13	1.4	0.6	0.5	1860	1989
c06pul av	130	54		3	21	2.4	0.8	0.4	1871	2000
c06pul av	115	52		3	14	1.5	0.5	0.7	1854	1983
c06pul av	123	54		2	13	1.4	0.4	0.2	1862	1991
c06pul av	129	54		2	25	2.9	0.1	0.6	1874	2003
c06pul av	128	53		2	9	1.1	0.4	0.3	1867	1996
c06pul av	127	53		1	13	1.4	0.5	0.0	1866	1995
c06pul av	124	53		1	14	1.6	0.2	0.3	1863	1992

Sample	(=HalfCh): c07obl av	0	114	1889	2002
Reference	(=HalfCh): 006pul av	0	134	1869	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c07obl av	114	58	*	13	14	1.5	2.0	2.3	1886	1999
c07obl av	113	59	*	11	8	0.9	2.1	1.8	1890	2003
c07obl av	114	58		11	35	4.0	2.3	1.5	1876	1989
c07obl av	114	53		8	35	4.0	1.6	1.2	1880	1993
c07obl av	114	55		7	30	3.4	1.6	0.8	1878	1991
c07obl av	114	52		7	32	3.6	1.7	0.8	1874	1987
c07obl av	114	52		7	2	0.2	1.8	0.8	1888	2001
c07obl av	112	53		6	8	0.8	0.9	1.3	1891	2004
c07obl av	114	52		5	34	3.8	1.1	0.8	1879	1992
c07obl av	114	50		5	38	4.4	1.3	0.7	1871	1984
c07obl av	114	65	***	3	24	2.7	0.0	1.0	1884	1997
c07obl av	110	56		3	16	1.7	0.2	1.0	1893	2006
c07obl av	113	55		3	39	4.4	0.3	0.9	1868	1981
c07obl av	114	52		2	37	4.3	0.5	0.3	1872	1985

Sample	(=HalfCh): c08ten av	0	93	1910	2002
Reference	(=HalfCh): 006pul av	0	134	1869	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c08ten av	93	65	**	25	37	3.8	3.6	4.0	1906	1998
c08ten av	93	42		12	26	2.5	3.2	2.6	1889	1981
c08ten av	93	56		10	37	3.8	1.5	2.0	1888	1980
c08ten av	93	37		10	6	0.6	2.5	2.7	1907	1999
c08ten av	93	57		9	-2	0.2	2.5	0.8	1910	2002
c08ten av	93	56		6	39	4.0	1.6	0.6	1899	1991
c08ten av	93	54		6	33	3.3	1.6	0.6	1891	1983
c08ten av	93	56		5	42	4.4	0.3	1.6	1904	1996
c08ten av	93	52		5	40	4.2	0.4	1.7	1905	1997
c08ten av	93	53		4	32	3.3	0.2	1.2	1902	1994
c08ten av	91	56		3	-17	1.6	0.8	0.2	1912	2004
c08ten av	93	53		3	33	3.3	0.4	0.8	1895	1987
c08ten av	93	55		2	33	3.3	0.0	0.8	1897	1989
c08ten av	93	52		2	31	3.1	0.2	0.4	1898	1990
c08ten av	93	57		1	33	3.4	0.3	0.0	1900	1992
c08ten av	93	52		1	30	3.0	0.3	0.1	1893	1985
c08ten av	93	52		1	31	3.2	0.4	0.0	1894	1986

Sample	(=HalfCh): c12ten av	0	138	1867	2004
Reference	(=HalfCh): 007ten av	0	94	1910	2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c12ten av	85	55		12	-7	0.6	2.6	2.0	1857	1994
c12ten av	83	57		10	10	0.9	1.9	1.7	1855	1992
c12ten av	78	59		9	2	0.2	0.9	2.3	1850	1987
c12ten av	90	55		7	8	0.7	1.9	0.6	1862	1999
c12ten av	87	53		7	15	1.4	1.9	1.1	1859	1996
c12ten av	93	55		6	7	0.7	0.9	1.2	1865	2002
c12ten av	76	51		6	-1	0.1	1.2	1.6	1848	1985
c12ten av	86	52		4	3	0.3	0.7	0.9	1858	1995
c12ten av	94	59	*	3	11	1.1	0.3	0.8	1867	2004
c12ten av	81	51		3	4	0.4	0.2	1.1	1853	1990
c12ten av	74	50		3	-29	2.6	0.9	0.5	1846	1983
c12ten av	72	57		2	-28	2.4	0.6	0.0	1844	1981
c12ten av	71	52		2	-31	2.7	0.3	0.6	1843	1980
c12ten av	73	51		2	-25	2.2	0.8	0.1	1845	1982
c12ten av	80	56		1	-1	0.1	0.3	0.1	1852	1989
c12ten av	94	52		1	9	0.9	0.1	0.3	1868	2005

Sample	(=HalfCh): 003Aobl av	0	122	1881	2002
Reference	(=HalfCh): 007ten av	0	94	1910	2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003Aobl av	94	58		17	33	3.4	3.5	2.6	1885	2006
003Aobl av	94	55		13	20	1.9	1.8	2.7	1882	2003
003Aobl av	72	60	*	12	41	3.7	2.5	2.0	1860	1981
003Aobl av	75	61	*	11	38	3.5	1.6	2.3	1863	1984
003Aobl av	81	54		7	37	3.5	1.5	1.3	1869	1990
003Aobl av	87	52		7	20	1.9	1.4	1.4	1875	1996
003Aobl av	91	62	*	5	5	0.5	1.4	0.2	1879	2000
003Aobl av	80	53		4	27	2.5	1.0	0.6	1868	1989
003Aobl av	85	54		3	25	2.3	0.5	0.6	1873	1994

003Aobl av	82	53		3	37	3.6	0.4	0.7	1870	1991
003Aobl av	77	50		3	13	1.2	0.2	1.1	1865	1986
003Aobl av	84	55		2	24	2.3	0.6	0.3	1872	1993
003Aobl av	88	53		2	8	0.8	0.5	0.2	1876	1997
003Aobl av	92	51		2	10	0.9	0.1	0.6	1880	2001
003Aobl av	94	50		2	26	2.6	0.6	0.2	1884	2005
003Aobl av	90	50		1	-2	0.2	0.3	0.1	1878	1999

Sample (=HalfCh): 003obl av 0 131 1872 2002
Reference (=HalfCh): 007ten av 0 94 1910 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003obl av	84	61	*	14	44	4.5	2.5	2.4	1863	1993
003obl av	87	46		11	17	1.6	2.7	2.5	1866	1996
003obl av	82	50		8	18	1.7	2.3	1.1	1861	1991
003obl av	94	56		7	40	4.2	1.7	0.7	1874	2004
003obl av	94	56		7	15	1.5	1.5	1.0	1876	2006
003obl av	89	55		7	27	2.6	1.8	0.8	1868	1998
003obl av	72	56		4	32	2.9	0.9	0.8	1851	1981
003obl av	85	55		4	38	3.8	1.4	0.0	1864	1994
003obl av	93	51		4	26	2.5	1.0	0.6	1872	2002
003obl av	81	51		3	21	1.9	0.3	0.7	1860	1990
003obl av	88	55		2	18	1.7	0.2	0.7	1867	1997
003obl av	78	54		2	10	0.9	0.4	0.5	1857	1987
003obl av	91	53		2	23	2.3	0.2	0.4	1870	2000
003obl av	79	53		2	20	1.7	0.6	0.2	1858	1988
003obl av	74	57		1	11	0.9	0.1	0.3	1853	1983
003obl av	71	52		1	34	3.0	0.2	0.1	1850	1980

Sample (=HalfCh): 004ten av 0 77 1926 2002
Reference (=HalfCh): 007ten av 0 94 1910 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
004ten av	77	41		15	-40	3.8	3.9	3.5	1917	1993
004ten av	77	54		13	17	1.5	2.0	2.7	1913	1989
004ten av	77	55		12	-9	0.8	2.2	2.0	1918	1994
004ten av	77	60	*	7	-3	0.3	0.9	1.5	1922	1998
004ten av	74	59		7	-13	1.1	1.1	1.2	1907	1983
004ten av	77	57		6	-11	1.0	1.0	1.1	1915	1991
004ten av	77	53		6	-32	2.9	1.5	0.8	1916	1992
004ten av	72	63	*	4	-14	1.2	0.4	0.7	1905	1981
004ten av	77	55		4	29	2.6	0.8	0.7	1926	2002
004ten av	77	53		4	30	2.8	0.6	0.7	1927	2003
004ten av	76	51		4	-28	2.5	0.7	0.9	1909	1985
004ten av	75	60	*	3	10	0.9	0.6	0.6	1929	2005
004ten av	77	60	*	3	-6	0.5	0.6	0.3	1920	1996
004ten av	77	55		2	3	0.3	0.3	0.5	1914	1990
004ten av	77	57		1	7	0.6	0.3	0.2	1924	2000
004ten av	77	53		1	-2	0.2	0.1	0.1	1912	1988
004ten av	75	50		1	-19	1.7	0.5	0.1	1908	1984

Sample (=HalfCh): 006pul av 0 134 1869 2002
Reference (=HalfCh): 007ten av 0 94 1910 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
006pul av	94	58		19	3	0.3	3.6	3.1	1870	2003
006pul av	76	57		14	-11	0.9	3.0	2.3	1852	1985
006pul av	83	62	*	12	25	2.3	2.1	2.0	1859	1992
006pul av	94	45		11	-2	0.2	3.3	1.7	1872	2005
006pul av	86	58		9	32	3.1	1.4	1.9	1862	1995
006pul av	80	54		8	-5	0.5	2.2	1.1	1856	1989
006pul av	81	51		6	-5	0.4	1.5	1.0	1857	1990
006pul av	92	58		4	-14	1.4	0.7	0.5	1868	2001
006pul av	88	53		2	13	1.2	0.3	0.5	1864	1997
006pul av	71	51		2	7	0.6	0.7	0.1	1847	1980
006pul av	85	58		1	28	2.7	0.0	0.4	1861	1994
006pul av	79	53		1	-18	1.6	0.3	0.2	1855	1988
006pul av	89	50		1	0	0.0	0.3	0.1	1865	1998
006pul av	73	58		0	-14	1.2	0.1	0.1	1849	1982

Sample (=HalfCh): 007ten av 0 94 1910 2003
Reference (=HalfCh): 007ten av 0 94 1910 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
007ten av	94	100	***	1000	100	100.0	100.0	100.0	1910	2003
007ten av	72	56		16	10	0.9	3.3	3.3	1888	1981
007ten av	92	43		11	33	3.3	4.5	0.8	1908	2001
007ten av	92	43		11	33	3.3	4.5	0.8	1912	2005
007ten av	93	40		11	55	6.2	1.5	3.8	1911	2004
007ten av	93	40		11	55	6.2	1.5	3.8	1909	2002
007ten av	73	44		10	-8	0.6	2.2	3.0	1889	1982
007ten av	82	53		9	21	1.9	1.6	2.2	1898	1991
007ten av	75	62	*	8	2	0.2	1.2	1.5	1891	1984
007ten av	79	61	*	5	9	0.8	0.8	0.8	1895	1988
007ten av	87	54		5	8	0.7	1.0	1.1	1903	1996
007ten av	85	51		5	-7	0.6	1.1	1.1	1901	1994
007ten av	88	56		4	15	1.4	1.3	0.1	1904	1997
007ten av	84	54		4	6	0.5	0.6	1.1	1900	1993
007ten av	89	54		3	18	1.7	0.2	0.8	1905	1998
007ten av	71	51		2	2	0.2	0.3	0.8	1887	1980
007ten av	76	50		2	0	0.0	0.2	0.5	1892	1985
007ten av	81	57		1	12	1.1	0.3	0.2	1897	1990

Sample (=HalfCh): 008ten av 0 99 1904 2002
Reference (=HalfCh): 007ten av 0 94 1910 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
008ten av	86	53		14	-14	1.3	1.9	3.6	1897	1995
008ten av	85	43		11	-28	2.7	2.1	3.5	1896	1994
008ten av	91	56		9	-12	1.2	1.9	1.2	1902	2000
008ten av	84	58		8	-16	1.4	1.1	1.8	1895	1993
008ten av	76	63	*	7	1	0.1	0.9	1.5	1887	1985
008ten av	94	60	*	7	-11	1.0	1.6	0.8	1908	2006
008ten av	82	53		6	-31	2.9	1.4	1.1	1893	1991
008ten av	93	57		5	-26	2.6	0.8	1.0	1904	2002
008ten av	94	55		5	-29	2.9	0.9	0.7	1906	2004
008ten av	79	51		4	5	0.4	1.0	0.7	1890	1988
008ten av	89	51		4	-21	2.0	0.8	1.0	1900	1998

008ten av	88	52		3	-21	2.0	0.3	1.0	1899	1997
008ten av	92	51		3	-21	2.0	0.9	0.1	1903	2001
008ten av	83	50		3	-27	2.5	1.1	0.0	1894	1992
008ten av	71	57		2	-34	3.0	0.2	0.5	1882	1980
008ten av	74	51		2	-23	2.0	0.2	0.9	1885	1983
008ten av	77	50		2	10	0.8	0.7	0.2	1888	1986
008ten av	78	60	*	1	12	1.0	0.3	0.0	1889	1987

Sample (=HalfCh): 009ten av 0 74 1929 2002
Reference (=HalfCh): 007ten av 0 94 1910 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
009ten av	71	57		16	19	1.6	3.3	2.4	1933	2006
009ten av	73	37		11	-16	1.3	3.3	2.8	1931	2004
009ten av	74	49		10	11	1.0	2.2	1.9	1913	1986
009ten av	74	58		8	10	0.9	1.4	1.2	1921	1994
009ten av	74	58		7	10	0.9	1.0	1.3	1910	1983
009ten av	74	57		7	16	1.3	1.9	0.4	1911	1984
009ten av	74	53		7	-22	1.9	1.5	1.0	1926	1999
009ten av	72	61	*	6	1	0.1	0.6	1.2	1908	1981
009ten av	74	56		6	35	3.2	1.0	1.3	1916	1989
009ten av	74	58		5	2	0.1	1.1	0.5	1928	2001
009ten av	74	54		4	32	2.8	0.7	0.8	1917	1990
009ten av	74	52		4	-6	0.5	0.8	0.8	1930	2003
009ten av	74	56		3	-11	0.9	0.6	0.6	1927	2000
009ten av	74	50		3	30	2.7	0.5	0.6	1918	1991
009ten av	74	53		2	-5	0.4	0.5	0.3	1929	2002
009ten av	74	54		1	-12	1.0	0.1	0.3	1923	1996
009ten av	74	54		1	37	3.4	0.5	0.0	1915	1988
009ten av	74	51		1	29	2.5	0.3	0.2	1914	1987
009ten av	74	51		1	-3	0.2	0.2	0.2	1922	1995

Sample (=HalfCh): c04obl av 0 155 1848 2002
Reference (=HalfCh): 007ten av 0 94 1910 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c04obl av	92	34		13	-4	0.4	3.1	4.6	1847	2001
c04obl av	89	53		12	23	2.2	2.4	2.0	1844	1998
c04obl av	93	57		11	13	1.3	1.2	2.6	1848	2002
c04obl av	79	58		8	-3	0.2	1.6	1.5	1834	1988
c04obl av	71	57		8	-8	0.6	1.6	1.5	1826	1980
c04obl av	74	56		8	-4	0.3	1.9	1.1	1829	1983
c04obl av	94	55		8	25	2.5	1.6	1.2	1852	2006
c04obl av	94	51		8	27	2.7	2.6	0.4	1849	2003
c04obl av	75	57		7	-4	0.3	1.7	1.1	1830	1984
c04obl av	83	50		6	11	1.0	1.5	1.0	1838	1992
c04obl av	91	53		5	6	0.6	0.2	1.7	1846	2000
c04obl av	80	52		4	-11	1.0	0.6	1.2	1835	1989
c04obl av	81	53		3	-8	0.7	1.3	0.1	1836	1990
c04obl av	90	56		2	15	1.4	0.6	0.0	1845	1999
c04obl av	84	58		1	8	0.7	0.1	0.2	1839	1993
c04obl av	94	54		1	24	2.3	0.2	0.1	1851	2005
c04obl av	78	53		1	-7	0.6	0.2	0.2	1833	1987
c04obl av	85	52		1	3	0.3	0.4	0.2	1840	1994

Sample	(=HalfCh):	c06pul av		0	130	1873	2002
Reference	(=HalfCh):	007ten av		0	94	1910	2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c06pul av	71	62	*	11	10	0.8	1.6	2.2	1851	1980
c06pul av	94	56		8	-3	0.3	1.5	1.3	1877	2006
c06pul av	94	53		6	-8	0.8	1.4	1.0	1874	2003
c06pul av	84	59		5	-6	0.6	0.5	1.2	1864	1993
c06pul av	86	57		5	-10	0.9	0.6	1.3	1866	1995
c06pul av	75	55		5	1	0.1	1.0	1.1	1855	1984
c06pul av	80	53		5	-13	1.2	1.7	0.5	1860	1989
c06pul av	89	56		4	2	0.2	0.7	0.9	1869	1998
c06pul av	79	51		4	-21	1.8	0.7	1.0	1859	1988
c06pul av	90	51		3	0	0.0	0.6	0.4	1870	1999
c06pul av	73	51		3	0	0.0	0.9	0.3	1853	1982
c06pul av	94	58		2	-13	1.2	0.5	0.2	1875	2004
c06pul av	77	55		2	-19	1.7	0.0	0.9	1857	1986
c06pul av	76	51		2	-19	1.7	0.3	0.6	1856	1985
c06pul av	91	51		2	-4	0.4	0.5	0.5	1871	2000
c06pul av	93	51		2	-13	1.3	0.4	0.3	1873	2002
c06pul av	88	50		2	-8	0.8	0.4	0.4	1868	1997
c06pul av	82	51		1	-11	1.0	0.3	0.3	1862	1991

Sample	(=HalfCh):	c07obl av		0	114	1889	2002
Reference	(=HalfCh):	007ten av		0	94	1910	2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c07obl av	80	64	**	17	12	1.1	2.9	2.9	1876	1989
c07obl av	87	61	*	8	9	0.9	1.2	1.6	1883	1996
c07obl av	94	58		8	29	3.0	0.7	2.0	1891	2004
c07obl av	90	53		8	37	3.7	1.8	1.3	1886	1999
c07obl av	93	51		8	48	5.2	1.3	1.7	1889	2002
c07obl av	72	51		7	-17	1.4	1.1	2.0	1868	1981
c07obl av	94	59	*	6	16	1.6	0.4	1.8	1893	2006
c07obl av	89	53		4	22	2.1	1.0	0.7	1885	1998
c07obl av	77	52		4	3	0.2	0.9	0.6	1873	1986
c07obl av	74	50		4	-14	1.2	0.7	0.8	1870	1983
c07obl av	92	46		4	47	5.0	0.9	0.8	1888	2001
c07obl av	82	56		3	-4	0.3	1.1	0.0	1878	1991
c07obl av	85	54		3	4	0.3	0.2	0.9	1881	1994
c07obl av	94	52		3	34	3.5	0.1	1.0	1890	2003
c07obl av	78	50		2	7	0.6	0.1	0.6	1874	1987
c07obl av	91	55		1	41	4.3	0.4	0.1	1887	2000
c07obl av	84	51		1	-3	0.3	0.1	0.4	1880	1993

Sample	(=HalfCh):	c08ten av		0	93	1910	2002
Reference	(=HalfCh):	007ten av		0	94	1910	2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c08ten av	93	93	***	96	96	32.3	14.4	6.2	1911	2003
c08ten av	92	44		16	31	3.1	4.5	3.0	1909	2001
c08ten av	72	55		15	9	0.8	3.2	3.1	1889	1981
c08ten av	91	47		12	34	3.4	3.9	1.2	1913	2005
c08ten av	82	53		11	22	2.1	1.9	2.5	1899	1991

c08ten av	79	62	*	7	12	1.0	1.4	1.2	1896	1988
c08ten av	75	61	*	6	2	0.2	0.9	1.4	1892	1984
c08ten av	87	54		6	7	0.7	1.1	1.2	1904	1996
c08ten av	81	56		4	11	1.0	0.9	0.5	1898	1990
c08ten av	88	55		4	14	1.3	1.3	0.1	1905	1997
c08ten av	90	52		4	22	2.2	0.9	0.8	1914	2006
c08ten av	92	39		4	58	6.8	1.1	1.1	1912	2004
c08ten av	84	55		3	4	0.3	0.2	1.1	1901	1993
c08ten av	89	55		3	18	1.7	0.1	0.9	1906	1998
c08ten av	76	51		2	2	0.2	0.6	0.2	1893	1985
c08ten av	71	50		2	-2	0.1	0.1	1.0	1888	1980
c08ten av	93	42		2	56	6.5	0.5	0.5	1910	2002

Sample (=HalfCh): c12ten av 0 138 1867 2004
Reference (=HalfCh): 008ten av 0 99 1904 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c12ten av	89	57		20	24	2.3	3.9	3.4	1855	1992
c12ten av	99	54		13	17	1.7	2.6	2.1	1869	2006
c12ten av	85	55		11	19	1.8	2.5	1.7	1851	1988
c12ten av	87	45		11	-11	1.0	3.5	1.7	1853	1990
c12ten av	99	55		8	13	1.3	1.4	1.6	1865	2002
c12ten av	99	52		8	3	0.2	1.8	1.1	1867	2004
c12ten av	91	59	*	7	3	0.3	0.5	2.1	1857	1994
c12ten av	93	57		7	-13	1.2	1.5	1.0	1859	1996
c12ten av	79	51		6	-3	0.2	1.5	1.2	1845	1982
c12ten av	82	64	**	5	23	2.1	1.4	0.3	1848	1985
c12ten av	99	51		5	17	1.7	1.1	0.9	1868	2005
c12ten av	95	55		3	0	0.0	0.8	0.2	1861	1998
c12ten av	83	50		3	15	1.4	0.6	0.6	1849	1986
c12ten av	77	51		2	5	0.5	0.2	0.7	1843	1980
c12ten av	94	51		1	-7	0.6	0.4	0.1	1860	1997

Sample (=HalfCh): 003Aobl av 0 122 1881 2002
Reference (=HalfCh): 008ten av 0 99 1904 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003Aobl av	90	68	***	14	-4	0.3	1.2	3.1	1872	1993
003Aobl av	82	61	*	14	12	1.1	2.0	3.0	1864	1985
003Aobl av	99	59	*	10	-18	1.8	1.4	2.0	1885	2006
003Aobl av	88	54		10	-15	1.4	1.8	2.2	1870	1991
003Aobl av	93	55		9	4	0.3	2.1	1.2	1875	1996
003Aobl av	86	51		7	-30	2.9	1.6	1.4	1868	1989
003Aobl av	99	50		5	-25	2.5	0.6	1.3	1884	2005
003Aobl av	99	52		4	-20	2.1	0.7	0.7	1883	2004
003Aobl av	92	56		3	-2	0.2	0.1	1.0	1874	1995
003Aobl av	97	52		3	-6	0.6	1.0	0.2	1879	2000
003Aobl av	96	51		3	-2	0.2	0.7	0.4	1878	1999
003Aobl av	79	50		3	-10	0.9	0.9	0.5	1861	1982
003Aobl av	99	59	*	2	-23	2.4	0.3	0.2	1882	2003
003Aobl av	78	56		2	-15	1.3	0.1	0.9	1860	1981
003Aobl av	83	56		2	4	0.4	0.0	0.8	1865	1986
003Aobl av	84	55		2	-8	0.7	0.1	0.5	1866	1987
003Aobl av	98	55		2	-17	1.7	0.5	0.1	1880	2001
003Aobl av	80	53		2	-5	0.4	0.5	0.4	1862	1983

Sample	(=HalfCh): 003obl av	0	131	1872	2002
Reference	(=HalfCh): 008ten av	0	99	1904	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003obl av	99	71	***	21	-18	1.8	2.1	3.9	1872	2002
003obl av	93	62	*	13	-18	1.7	2.2	2.3	1866	1996
003obl av	80	54		13	16	1.4	2.6	2.8	1853	1983
003obl av	98	32		12	-39	4.1	3.2	4.2	1871	2001
003obl av	97	60	*	7	-28	2.8	0.6	1.9	1870	2000
003obl av	99	58		7	-14	1.4	0.5	1.9	1874	2004
003obl av	89	60	*	5	-23	2.2	0.9	0.7	1862	1992
003obl av	91	51		5	-27	2.6	1.5	0.6	1864	1994
003obl av	78	53		4	-5	0.4	1.7	0.2	1851	1981
003obl av	95	61	*	3	-32	3.3	0.8	0.3	1868	1998
003obl av	99	58		3	-19	1.9	0.1	0.8	1876	2006
003obl av	82	51		2	4	0.3	0.2	0.8	1855	1985
003obl av	87	52		1	-23	2.2	0.3	0.0	1860	1990
003obl av	85	58		0	-25	2.4	0.1	0.0	1858	1988

Sample	(=HalfCh): 004ten av	0	77	1926	2002
Reference	(=HalfCh): 008ten av	0	99	1904	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
004ten av	74	65	**	15	26	2.3	2.3	2.3	1929	2005
004ten av	77	59		11	23	2.0	2.0	1.9	1908	1984
004ten av	77	45		11	-21	1.9	2.3	2.7	1913	1989
004ten av	77	67	**	10	1	0.1	1.2	1.7	1914	1990
004ten av	77	52		10	13	1.1	1.9	1.9	1918	1994
004ten av	77	57		7	-6	0.5	1.0	1.6	1912	1988
004ten av	77	55		7	10	0.9	0.9	1.8	1922	1998
004ten av	77	55		4	11	1.0	0.2	1.2	1920	1996
004ten av	77	52		4	-6	0.5	1.4	0.3	1916	1992
004ten av	76	58		2	10	0.9	0.1	0.6	1927	2003
004ten av	77	54		2	6	0.5	0.3	0.5	1905	1981
004ten av	77	51		2	7	0.6	0.5	0.3	1909	1985
004ten av	77	51		2	-5	0.5	0.6	0.4	1924	2000
004ten av	77	51		2	-8	0.7	0.5	0.4	1925	2001
004ten av	77	50		2	2	0.2	0.6	0.2	1906	1982

Sample	(=HalfCh): 006pul av	0	134	1869	2002
Reference	(=HalfCh): 008ten av	0	99	1904	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
006pul av	99	55		10	-10	1.0	1.6	1.9	1871	2004
006pul av	96	59	*	9	-2	0.2	1.7	1.3	1866	1999
006pul av	85	57		7	13	1.2	1.0	1.6	1855	1988
006pul av	77	67	**	6	-12	1.1	0.7	1.2	1847	1980
006pul av	87	62	*	6	4	0.4	0.6	1.4	1857	1990
006pul av	91	62	*	5	-9	0.9	0.8	0.8	1861	1994
006pul av	97	51		5	-15	1.5	1.0	0.9	1867	2000
006pul av	94	53		4	-4	0.4	0.6	0.8	1864	1997
006pul av	83	58		2	-3	0.3	0.6	0.1	1853	1986

006pul av	95	51		2	-9	0.9	0.4	0.4	1865	1998
006pul av	79	62	*	1	-12	1.0	0.2	0.2	1849	1982
006pul av	81	56		1	-12	1.1	0.3	0.0	1851	1984
006pul av	98	53		1	-18	1.7	0.2	0.2	1868	2001

Sample (=HalfCh): 007ten av 0 94 1910 2003
Reference (=HalfCh): 008ten av 0 99 1904 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
007ten av	79	64	**	14	21	1.8	2.5	2.0	1889	1982
007ten av	85	55		13	-11	1.0	2.8	2.4	1895	1988
007ten av	91	56		9	-12	1.2	1.9	1.2	1912	2005
007ten av	94	60	*	7	-11	1.0	1.6	0.8	1906	1999
007ten av	90	54		7	-13	1.2	1.3	1.5	1900	1993
007ten av	93	57		5	-26	2.6	0.8	1.0	1910	2003
007ten av	94	55		5	-29	2.9	0.9	0.7	1908	2001
007ten av	94	53		5	-14	1.4	1.1	0.7	1904	1997
007ten av	83	52		4	-13	1.2	1.2	0.3	1893	1986
007ten av	86	57		3	-23	2.2	0.0	1.0	1896	1989
007ten av	87	52		3	-24	2.3	0.9	0.3	1897	1990
007ten av	92	51		3	-21	2.0	0.9	0.1	1911	2004
007ten av	91	51		2	-15	1.4	0.5	0.3	1901	1994
007ten av	88	51		2	-21	2.0	0.3	0.5	1898	1991
007ten av	81	53		1	12	1.1	0.0	0.5	1891	1984
007ten av	78	50		1	5	0.5	0.1	0.1	1888	1981
007ten av	92	53		0	-11	1.0	0.0	0.0	1902	1995

Sample (=HalfCh): 008ten av 0 99 1904 2002
Reference (=HalfCh): 008ten av 0 99 1904 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
008ten av	99	100	***	1000	100	100.0	100.0	100.0	1904	2002
008ten av	98	40		16	39	4.2	2.7	5.3	1903	2001
008ten av	98	40		16	39	4.2	2.7	5.3	1905	2003
008ten av	82	58		13	22	2.1	2.4	2.6	1887	1985
008ten av	78	61	*	12	42	4.0	2.3	2.0	1883	1981
008ten av	85	58		12	26	2.4	2.7	1.7	1890	1988
008ten av	97	57		12	38	4.0	2.8	1.3	1902	2000
008ten av	97	57		12	38	4.0	2.8	1.3	1906	2004
008ten av	89	61	*	7	25	2.4	1.1	1.4	1894	1992
008ten av	95	60	*	7	32	3.2	1.1	1.3	1900	1998
008ten av	95	60	*	7	32	3.2	1.1	1.3	1908	2006
008ten av	93	57		7	29	2.9	0.8	1.8	1898	1996
008ten av	91	58		5	22	2.2	0.2	1.5	1896	1994
008ten av	86	50		5	17	1.6	1.0	1.1	1891	1989
008ten av	84	50		1	17	1.6	0.6	0.1	1889	1987

Sample (=HalfCh): 009ten av 0 74 1929 2002
Reference (=HalfCh): 008ten av 0 99 1904 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
009ten av	74	59		9	4	0.3	1.3	1.7	1923	1996
009ten av	74	62	*	6	16	1.4	0.9	0.9	1913	1986
009ten av	74	60	*	6	0	0.0	0.8	1.1	1919	1992

009ten av	74	51		5	-5	0.4	1.1	0.8	1928	2001
009ten av	73	59		4	9	0.8	1.0	0.4	1930	2003
009ten av	74	51		4	-3	0.2	0.8	0.8	1922	1995
009ten av	74	54		3	-3	0.2	0.4	0.7	1907	1980
009ten av	74	54		3	1	0.1	0.1	1.0	1911	1984
009ten av	74	52		3	-2	0.1	1.1	0.2	1921	1994
009ten av	74	60	*	2	-3	0.3	0.3	0.5	1915	1988
009ten av	74	58		2	-1	0.1	0.2	0.6	1927	2000
009ten av	74	55		2	0	0.0	0.2	0.7	1925	1998
009ten av	74	55		2	-7	0.6	0.4	0.2	1917	1990
009ten av	71	53		2	-5	0.4	0.4	0.4	1932	2005
009ten av	74	51		2	9	0.7	0.1	0.5	1914	1987
009ten av	70	51		1	-13	1.1	0.0	0.4	1933	2006
009ten av	72	51		1	3	0.2	0.3	0.2	1931	2004
009ten av	74	50		1	5	0.4	0.2	0.4	1929	2002

Sample (=HalfCh): c04obl av 0 155 1848 2002
Reference (=HalfCh): 008ten av 0 99 1904 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c04obl av	82	58		8	-9	0.8	1.4	1.5	1831	1985
c04obl av	99	55		7	-22	2.2	1.1	1.4	1851	2005
c04obl av	79	55		6	-13	1.1	1.1	1.4	1828	1982
c04obl av	78	53		6	-26	2.4	1.2	1.4	1827	1981
c04obl av	96	56		4	-6	0.6	0.9	0.7	1845	1999
c04obl av	92	55		3	-17	1.7	0.7	0.6	1841	1995
c04obl av	84	51		3	-5	0.4	0.3	1.0	1833	1987
c04obl av	97	51		3	-10	1.0	0.6	0.4	1846	2000
c04obl av	89	54		2	-18	1.7	0.5	0.2	1838	1992
c04obl av	86	54		2	-12	1.1	0.5	0.4	1835	1989
c04obl av	81	51		2	-18	1.6	0.5	0.3	1830	1984
c04obl av	85	53		1	-4	0.3	0.4	0.0	1834	1988
c04obl av	77	51		1	-21	1.8	0.3	0.2	1826	1980
c04obl av	99	51		1	-17	1.7	0.4	0.1	1849	2003
c04obl av	95	51		1	-11	1.1	0.4	0.1	1844	1998
c04obl av	90	55		0	-19	1.8	0.0	0.1	1839	1993

Sample (=HalfCh): c06pul av 0 130 1873 2002
Reference (=HalfCh): 008ten av 0 99 1904 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c06pul av	82	61	*	13	27	2.5	1.9	2.7	1856	1985
c06pul av	90	62	*	8	35	3.5	1.3	1.5	1864	1993
c06pul av	99	53		7	10	1.0	0.9	1.7	1873	2002
c06pul av	88	59		5	35	3.5	0.8	1.1	1862	1991
c06pul av	97	53		5	16	1.5	0.6	1.1	1871	2000
c06pul av	84	57		4	22	2.0	0.0	1.4	1858	1987
c06pul av	80	54		4	7	0.7	0.3	1.2	1854	1983
c06pul av	94	54		3	11	1.0	0.7	0.6	1868	1997
c06pul av	86	65	**	2	21	1.9	0.4	0.2	1860	1989
c06pul av	78	61	*	2	-5	0.4	0.4	0.4	1852	1981
c06pul av	91	50		2	26	2.5	0.0	0.6	1865	1994
c06pul av	92	52		1	27	2.7	0.3	0.2	1866	1995
c06pul av	99	52		1	3	0.3	0.1	0.4	1877	2006

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Sample    (=HalfCh): c07obl av                          0     114  1889  2002
Reference (=HalfCh): 008ten av                          0      99  1904  2002

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
c07obl av    91  54        13    8   0.8   2.3   2.8   1881   1994
c07obl av    95  57        11    4   0.4   2.1   1.9   1885   1998
c07obl av    99  59 *       7   12   1.2   1.4   1.1   1890   2003
c07obl av    99  57         7    7   0.7   1.7   0.7   1891   2004
c07obl av    78  57         7   38   3.6   1.2   1.6   1868   1981
c07obl av    99  52         6   -3   0.3   1.7   0.8   1892   2005
c07obl av    85  51         4    5   0.5   1.5   0.4   1875   1988
c07obl av    82  56         3    2   0.2   0.3   0.9   1872   1985
c07obl av    97  55         3   -4   0.4   0.8   0.4   1887   2000
c07obl av    93  54         2    5   0.5   0.4   0.5   1883   1996
c07obl av    80  53         2   24   2.1   0.2   0.8   1870   1983
c07obl av    89  52         2   -2   0.1   0.9   0.1   1879   1992
c07obl av    84  52         2    0   0.0   0.3   0.4   1874   1987
c07obl av    86  52         2    8   0.7   0.6   0.4   1876   1989
c07obl av    99  52         2    6   0.6   0.3   0.3   1889   2002
c07obl av    98  50         2    2   0.2   0.4   0.4   1888   2001
c07obl av    88  52         1    6   0.5   0.0   0.2   1878   1991
c07obl av    87  50         1    7   0.7   0.3   0.4   1877   1990
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Sample    (=HalfCh): c08ten av                          0      93  1910  2002
Reference (=HalfCh): 008ten av                          0      99  1904  2002

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
c08ten av    79  65 **     13   20   1.7   2.4   1.9   1890   1982
c08ten av    90  57        13   -8   0.7   2.3   2.4   1913   2005
c08ten av    85  56        13  -12   1.1   2.6   2.2   1896   1988
c08ten av    93  59 *       8  -10   1.0   1.5   1.1   1907   1999
c08ten av    90  52         5  -16   1.5   0.6   1.2   1901   1993
c08ten av    92  57         4  -22   2.1   0.2   1.1   1911   2003
c08ten av    81  54         4   16   1.4   0.5   1.0   1892   1984
c08ten av    88  52         4  -20   1.9   0.3   1.2   1899   1991
c08ten av    83  50         4  -14   1.2   1.3   0.4   1894   1986
c08ten av    93  53         3  -28   2.8   1.0   0.3   1909   2001
c08ten av    87  51         3  -23   2.2   0.8   0.5   1898   1990
c08ten av    93  56         2  -14   1.4   0.6   0.2   1905   1997
c08ten av    86  55         2  -23   2.1   0.0   0.9   1897   1989
c08ten av    92  51         2  -13   1.2   0.4   0.2   1903   1995
c08ten av    91  54         0  -14   1.3   0.0   0.1   1902   1994
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Sample    (=HalfCh): c12ten av                          0     138  1867  2004
Reference (=HalfCh): 009ten av                          0      74  1929  2002

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
c12ten av    73  68 **     13   12   1.0   2.1   1.8   1864   2001
c12ten av    67  67 **     13  -17   1.4   2.5   1.6   1858   1995
c12ten av    74  53        10    5   0.4   1.6   2.1   1867   2004
c12ten av    56  68 **      8   19   1.4   1.3   1.4   1847   1984
c12ten av    72  56         7    9   0.7   1.4   1.2   1863   2000
c12ten av    55  52         4   24   1.8   0.9   0.7   1846   1983
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c12ten av	53	50		4	-3	0.2	1.2	0.8	1844	1981
c12ten av	74	63	*	3	8	0.6	0.4	0.5	1869	2006
c12ten av	59	50		3	-2	0.1	0.6	0.5	1850	1987
c12ten av	62	56		2	-21	1.7	0.5	0.5	1853	1990
c12ten av	58	53		2	6	0.5	0.3	0.5	1849	1986
c12ten av	64	52		2	-35	2.9	0.4	0.4	1855	1992
c12ten av	68	52		0	-24	2.0	0.1	0.1	1859	1996

Sample (=HalfCh): 003Aobl av 0 122 1881 2002
Reference (=HalfCh): 009ten av 0 74 1929 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003Aobl av	74	60	*	19	44	4.1	3.6	2.8	1881	2002
003Aobl av	55	63	*	11	-11	0.8	1.8	2.0	1862	1983
003Aobl av	67	61	*	11	34	2.9	2.3	1.5	1874	1995
003Aobl av	54	41		11	-34	2.6	3.1	3.1	1861	1982
003Aobl av	74	56		6	21	1.8	1.0	1.0	1884	2005
003Aobl av	53	56		6	-25	1.8	1.6	0.9	1860	1981
003Aobl av	52	53		6	-6	0.4	1.4	1.1	1859	1980
003Aobl av	73	50		6	46	4.4	1.4	1.1	1880	2001
003Aobl av	57	55		4	-7	0.5	0.2	1.5	1864	1985
003Aobl av	69	54		4	20	1.7	0.7	0.6	1876	1997
003Aobl av	74	53		4	22	1.9	1.3	0.3	1882	2003
003Aobl av	61	50		4	-9	0.7	1.1	0.5	1868	1989
003Aobl av	58	53		2	-13	1.0	0.4	0.2	1865	1986
003Aobl av	63	50		2	1	0.0	1.0	0.0	1870	1991
003Aobl av	66	57		1	24	2.0	0.2	0.1	1873	1994
003Aobl av	62	56		1	-3	0.2	0.0	0.3	1869	1990
003Aobl av	65	53		1	25	2.1	0.3	0.3	1872	1993
003Aobl av	64	51		1	14	1.1	0.3	0.1	1871	1992
003Aobl av	71	51		1	23	1.9	0.5	0.1	1878	1999

Sample (=HalfCh): 003obl av 0 131 1872 2002
Reference (=HalfCh): 009ten av 0 74 1929 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003obl av	66	65	**	14	31	2.6	2.9	1.8	1864	1994
003obl av	61	57		14	47	4.1	2.9	2.3	1859	1989
003obl av	68	43		10	-11	0.9	2.8	2.0	1866	1996
003obl av	63	42		10	-4	0.3	3.1	2.2	1861	1991
003obl av	60	54		8	52	4.7	2.4	0.9	1858	1988
003obl av	74	53		6	32	2.9	1.4	0.8	1875	2005
003obl av	62	53		6	18	1.4	1.7	0.7	1860	1990
003obl av	70	52		6	6	0.5	1.6	1.0	1868	1998
003obl av	58	58		5	4	0.3	1.0	0.8	1856	1986
003obl av	56	52		3	-5	0.4	0.3	0.8	1854	1984
003obl av	64	56		2	14	1.1	0.1	0.7	1862	1992
003obl av	74	54		2	21	1.8	0.1	0.7	1876	2006
003obl av	52	54		2	-22	1.6	0.6	0.2	1850	1980
003obl av	54	54		2	-4	0.3	1.0	0.0	1852	1982
003obl av	71	54		2	4	0.4	0.1	0.8	1869	1999
003obl av	59	54		2	18	1.4	0.6	0.2	1857	1987
003obl av	72	52		2	2	0.2	0.2	0.6	1870	2000
003obl av	69	50		2	-10	0.8	0.8	0.2	1867	1997
003obl av	73	56		1	1	0.1	0.0	0.3	1871	2001

003obl av	74	51		1	15	1.3	0.4	0.1	1873	2003
003obl av	74	51		1	26	2.2	0.3	0.3	1874	2004
003obl av	67	52		0	11	0.9	0.0	0.1	1865	1995

Sample	(=HalfCh): 004ten av	0	77	1926	2002
Reference	(=HalfCh): 009ten av	0	74	1929	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
004ten av	74	58		6	-13	1.1	0.7	1.2	1926	2002
004ten av	74	58		5	-14	1.2	0.5	1.3	1928	2004
004ten av	56	51		5	43	3.5	1.4	0.8	1908	1984
004ten av	59	57		4	3	0.2	0.6	0.9	1911	1987
004ten av	73	50		4	-26	2.3	0.9	0.7	1930	2006
004ten av	65	58		3	-16	1.3	0.8	0.5	1917	1993
004ten av	61	55		3	-6	0.5	0.5	0.7	1913	1989
004ten av	54	51		3	25	1.9	0.7	0.6	1906	1982
004ten av	66	51		3	-18	1.4	0.9	0.5	1918	1994
004ten av	63	63	*	2	-7	0.6	0.2	0.3	1915	1991
004ten av	71	57		2	-5	0.4	0.7	0.1	1923	1999
004ten av	55	56		2	24	1.8	0.6	0.3	1907	1983
004ten av	57	55		2	34	2.6	0.2	0.7	1909	1985
004ten av	67	53		2	-22	1.8	0.0	0.9	1919	1995
004ten av	74	52		1	-21	1.9	0.0	0.5	1929	2005

Sample	(=HalfCh): 006pul av	0	134	1869	2002
Reference	(=HalfCh): 009ten av	0	74	1929	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
006pul av	70	63	*	11	-7	0.6	1.7	1.9	1865	1998
006pul av	57	63	*	10	19	1.4	1.8	1.6	1852	1985
006pul av	73	43		10	-29	2.6	2.8	1.9	1868	2001
006pul av	54	61		9	25	1.9	2.1	1.2	1849	1982
006pul av	74	53		8	18	1.5	1.9	1.2	1870	2003
006pul av	66	58		6	-15	1.2	0.7	1.4	1861	1994
006pul av	62	54		6	28	2.2	0.8	1.8	1857	1990
006pul av	74	56		5	25	2.2	1.0	0.8	1871	2004
006pul av	74	53		3	-6	0.5	0.5	0.5	1869	2002
006pul av	65	50		3	-6	0.5	0.5	0.9	1860	1993
006pul av	68	62	*	2	-21	1.8	0.4	0.2	1863	1996
006pul av	60	61	*	2	19	1.5	0.3	0.6	1855	1988
006pul av	52	53		2	8	0.5	0.7	0.0	1847	1980
006pul av	74	51		2	29	2.6	0.1	0.5	1873	2006

Sample	(=HalfCh): 007ten av	0	94	1910	2003
Reference	(=HalfCh): 009ten av	0	74	1929	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
007ten av	71	57		16	19	1.6	3.3	2.4	1906	1999
007ten av	64	57		11	5	0.4	2.0	2.1	1899	1992
007ten av	52	57		11	25	1.9	2.4	2.2	1887	1980
007ten av	73	37		11	-16	1.3	3.3	2.8	1908	2001
007ten av	70	56		10	23	2.0	1.8	1.8	1905	1998
007ten av	61	47		10	-18	1.4	1.8	2.8	1896	1989
007ten av	65	58		8	2	0.1	1.8	1.1	1900	1993

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
007ten av	53	60		7	40	3.1	1.5	1.0	1888	1981
007ten av	66	55		7	-17	1.4	1.2	1.3	1901	1994
007ten av	74	53		7	-22	1.9	1.5	1.0	1913	2006
007ten av	74	58		5	2	0.1	1.1	0.5	1911	2004
007ten av	59	55		4	25	1.9	1.3	0.3	1894	1987
007ten av	74	52		4	-6	0.5	0.8	0.8	1909	2002
007ten av	62	51		4	-12	0.9	0.6	0.9	1897	1990
007ten av	55	56		3	17	1.2	1.0	0.2	1890	1983
007ten av	74	56		3	-11	0.9	0.6	0.6	1912	2005
007ten av	69	54		3	3	0.2	1.0	0.1	1904	1997
007ten av	68	53		3	-14	1.1	0.7	0.6	1903	1996
007ten av	57	55		2	18	1.3	0.2	0.8	1892	1985
007ten av	74	53		2	-5	0.4	0.5	0.3	1910	2003

Sample (=HalfCh): 008ten av 0 99 1904 2002
Reference (=HalfCh): 009ten av 0 74 1929 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
008ten av	64	55		5	-29	2.4	0.9	1.0	1894	1992
008ten av	74	51		5	-5	0.4	1.1	0.8	1905	2003
008ten av	73	59		4	9	0.8	1.0	0.4	1903	2001
008ten av	56	57		4	-12	0.9	0.8	0.9	1886	1984
008ten av	58	54		3	-18	1.3	0.5	0.7	1888	1986
008ten av	66	50		3	-22	1.8	0.6	0.5	1896	1994
008ten av	74	58		2	-1	0.1	0.2	0.6	1906	2004
008ten av	68	58		2	-14	1.1	0.2	0.4	1898	1996
008ten av	62	55		2	-35	2.9	0.6	0.1	1892	1990
008ten av	74	55		2	0	0.0	0.2	0.7	1908	2006
008ten av	71	53		2	-5	0.4	0.4	0.4	1901	1999
008ten av	60	60		1	-30	2.4	0.3	0.0	1890	1988
008ten av	52	57		1	-18	1.3	0.2	0.4	1882	1980
008ten av	54	55		1	-14	1.0	0.3	0.0	1884	1982
008ten av	63	52		1	-36	3.0	0.2	0.0	1893	1991
008ten av	70	51		1	-13	1.1	0.0	0.4	1900	1998
008ten av	72	51		1	3	0.2	0.3	0.2	1902	2000
008ten av	59	51		1	-31	2.4	0.2	0.1	1889	1987
008ten av	74	50		1	5	0.4	0.2	0.4	1904	2002

Sample (=HalfCh): 009ten av 0 74 1929 2002
Reference (=HalfCh): 009ten av 0 74 1929 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
009ten av	74	100	***	1000	100	100.0	100.0	100.0	1929	2002
009ten av	72	49		19	21	1.8	5.2	2.5	1927	2000
009ten av	72	49		19	21	1.8	5.2	2.5	1931	2004
009ten av	62	59		12	2	0.2	2.4	1.8	1917	1990
009ten av	58	64	*	10	27	2.1	1.5	2.0	1913	1986
009ten av	57	58		10	34	2.7	2.3	1.6	1912	1985
009ten av	68	58		8	24	2.0	1.6	1.2	1923	1996
009ten av	60	51		8	-13	1.0	2.0	1.6	1915	1988
009ten av	69	59		6	26	2.2	1.1	1.0	1924	1997
009ten av	54	52		6	-18	1.3	1.5	1.2	1909	1982
009ten av	56	52		4	14	1.0	0.7	1.0	1911	1984
009ten av	52	64	*	3	-2	0.1	0.5	0.6	1907	1980

009ten av	63	63	*	3	-7	0.6	0.5	0.6	1918	1991
009ten av	66	54		3	-5	0.4	0.8	0.4	1921	1994
009ten av	73	48		2	61	6.5	0.5	0.4	1930	2003
009ten av	73	48		2	61	6.5	0.5	0.4	1928	2001
009ten av	61	52		1	-5	0.4	0.3	0.1	1916	1989

Sample (=HalfCh): c04obl av 0 155 1848 2002
Reference (=HalfCh): 009ten av 0 74 1929 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c04obl av	71	60	*	15	10	0.9	3.0	2.0	1845	1999
c04obl av	54	61		13	42	3.3	2.9	1.9	1828	1982
c04obl av	73	49		11	-15	1.3	2.7	1.8	1847	2001
c04obl av	59	60		10	56	5.2	1.7	2.0	1833	1987
c04obl av	74	55		10	9	0.8	2.1	1.4	1849	2003
c04obl av	65	59		6	21	1.7	1.2	1.2	1839	1993
c04obl av	53	58		6	34	2.6	1.2	1.0	1827	1981
c04obl av	69	51		6	-2	0.1	1.5	0.9	1843	1997
c04obl av	61	63	*	5	23	1.8	1.0	0.8	1835	1989
c04obl av	52	55		5	16	1.2	1.3	0.8	1826	1980
c04obl av	74	60	*	4	4	0.4	0.2	1.2	1851	2005
c04obl av	55	54		4	27	2.0	1.2	0.4	1829	1983
c04obl av	68	53		4	-5	0.4	0.7	1.0	1842	1996
c04obl av	60	50		3	42	3.6	0.7	0.8	1834	1988
c04obl av	74	51		2	8	0.7	0.2	0.5	1850	2004
c04obl av	63	57		1	12	0.9	0.3	0.2	1837	1991
c04obl av	66	53		1	11	0.9	0.5	0.1	1840	1994

Sample (=HalfCh): c06pul av 0 130 1873 2002
Reference (=HalfCh): 009ten av 0 74 1929 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c06pul av	74	53		10	8	0.7	1.9	1.9	1874	2003
c06pul av	71	70	***	9	-12	1.0	1.2	1.3	1870	1999
c06pul av	63	52		9	19	1.5	2.0	1.7	1862	1991
c06pul av	60	58		8	18	1.4	2.2	0.9	1859	1988
c06pul av	74	58		5	-8	0.7	1.5	0.4	1876	2005
c06pul av	69	57		5	-5	0.4	0.1	1.5	1868	1997
c06pul av	73	54		5	-7	0.6	1.4	0.6	1872	2001
c06pul av	53	54		4	-29	2.2	1.1	0.8	1852	1981
c06pul av	55	69	**	3	-18	1.3	0.3	0.6	1854	1983
c06pul av	64	56		3	16	1.3	0.8	0.5	1863	1992
c06pul av	57	54		3	-8	0.6	0.2	1.1	1856	1985
c06pul av	67	50		3	3	0.2	0.9	0.5	1866	1995
c06pul av	66	55		2	3	0.3	0.6	0.1	1865	1994

Sample (=HalfCh): c07obl av 0 114 1889 2002
Reference (=HalfCh): 009ten av 0 74 1929 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c07obl av	57	57		13	-6	0.5	2.2	2.8	1872	1985
c07obl av	69	54		8	-9	0.8	1.6	1.6	1884	1997
c07obl av	65	55		6	-23	1.8	1.3	0.9	1880	1993
c07obl av	55	54		6	-23	1.8	1.6	0.8	1870	1983

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c07obl av     52  53          4   -29   2.1    1.3    0.7   1867    1980
c07obl av     63  55          3   -28   2.3    0.2    0.9   1878    1991
c07obl av     54  51          3   -29   2.2    0.7    0.5   1869    1982
c07obl av     71  55          2   -12   1.0    0.7    0.1   1886    1999
c07obl av     74  51          2    -2   0.2    0.6    0.3   1892    2005
c07obl av     61  57          1   -30   2.4    0.1    0.3   1876    1989
c07obl av     74  56          1    -4   0.4    0.3    0.2   1889    2002

c07obl av     72  51          1    -6   0.5    0.1    0.2   1887    2000
c07obl av     74  50          1    -2   0.2    0.2    0.2   1890    2003
-----------------------------------------------------------------

Sample    (=HalfCh): c08ten av                           0       93  1910   2002
Reference (=HalfCh): 009ten av                           0       74  1929   2002

  Sample    OVL Glk GSL    CDI  %CC     TV  TVBP  TVH    DateL  DateR
c08ten av     71  56         14    22   1.9    3.0    2.3   1907    1999
c08ten av     64  59         12     5   0.4    2.3    2.1   1900    1992
c08ten av     52  55         11    27   2.0    2.4    2.1   1888    1980
c08ten av     61  45         11   -22   1.7    2.3    3.3   1897    1989
c08ten av     73  39         11   -12   1.0    3.0    2.5   1909    2001
c08ten av     65  56          9     2   0.2    2.0    1.4   1901    1993
c08ten av     53  62 *        8    42   3.3    1.7    1.3   1889    1981
c08ten av     66  53          8   -20   1.6    1.7    1.6   1902    1994
c08ten av     70  57          7    22   1.9    1.1    1.2   1906    1998
c08ten av     74  54          6   -20   1.7    1.2    0.8   1914    2006
c08ten av     59  54          6    25   2.0    1.9    0.6   1895    1987
c08ten av     58  51          6    32   2.5    1.5    1.1   1894    1986
c08ten av     74  54          4   -10   0.9    0.7    0.7   1913    2005
c08ten av     74  57          3     0   0.0    0.9    0.3   1912    2004
c08ten av     69  55          3     4   0.3    0.8    0.2   1905    1997
c08ten av     74  51          3    -6   0.5    0.5    0.5   1910    2002
c08ten av     55  54          2    23   1.7    0.7    0.1   1891    1983
c08ten av     57  54          2    18   1.3    0.2    0.7   1893    1985
c08ten av     74  52          2    -5   0.4    0.4    0.3   1911    2003
c08ten av     72  50          2     4   0.3    0.7    0.1   1908    2000
c08ten av     68  55          1   -11   0.9    0.1    0.2   1904    1996
-----------------------------------------------------------------

Sample    (=HalfCh): c12ten av                           0      138  1867   2004
Reference (=HalfCh): c04obl av                           0      155  1848   2002

  Sample    OVL Glk GSL    CDI  %CC     TV  TVBP  TVH    DateL  DateR
c12ten av    138  61 **      14    13   1.5    2.9    1.8   1855    1992
c12ten av    138  54         10     9   1.0    1.7    1.9   1852    1989
c12ten av    138  43         10    -3   0.3    2.8    1.8   1853    1990
c12ten av    138  54          7    17   2.0    1.1    1.3   1862    1999
c12ten av    138  53          6    10   1.2    0.9    1.2   1848    1985
c12ten av    138  57 *        5    12   1.4    0.4    1.4   1850    1987
c12ten av    134  53          4     6   0.7    1.0    0.6   1869    2006
c12ten av    134  52          4    17   1.9    1.0    0.6   1844    1981
c12ten av    136  57 *        3    14   1.6    0.7    0.4   1867    2004
c12ten av    137  50          3    12   1.4    0.8    0.2   1847    1984
c12ten av    138  50          3     7   0.8    0.7    0.5   1857    1994
c12ten av    138  57 *        2    20   2.4    0.2    0.6   1864    2001
c12ten av    138  52          2     6   0.7    0.4    0.3   1858    1995
c12ten av    138  58 *        1     9   1.1    0.2    0.1   1861    1998
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Sample (=HalfCh): 003Aobl av	0	122	1881	2002
Reference (=HalfCh): c04obl av	0	155	1848	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003Aobl av	122	56		7	19	2.1	1.0	1.7	1869	1990
003Aobl av	122	55		7	18	2.0	1.3	1.2	1873	1994
003Aobl av	122	57		6	23	2.6	1.1	1.2	1865	1986
003Aobl av	121	55		6	25	2.8	1.2	0.9	1882	2003
003Aobl av	122	51		5	13	1.4	1.5	0.6	1871	1992
003Aobl av	122	51		5	22	2.5	0.7	1.3	1867	1988
003Aobl av	122	54		4	18	2.1	1.3	0.3	1861	1982
003Aobl av	122	50		4	23	2.6	0.6	1.0	1878	1999
003Aobl av	122	50		4	15	1.6	0.8	0.8	1875	1996
003Aobl av	122	55		3	20	2.2	0.7	0.4	1868	1989
003Aobl av	122	50		3	23	2.6	0.5	0.5	1866	1987
003Aobl av	122	58	*	2	25	2.9	0.5	0.0	1879	2000

Sample (=HalfCh): 003obl av	0	131	1872	2002
Reference (=HalfCh): c04obl av	0	155	1848	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003obl av	128	50		11	13	1.5	2.8	1.6	1875	2005
003obl av	131	54		10	30	3.6	2.2	1.4	1863	1993
003obl av	131	50		8	19	2.2	1.5	1.5	1866	1996
003obl av	131	58	*	7	27	3.2	1.0	1.3	1867	1997
003obl av	131	55		7	44	5.5	1.5	1.0	1855	1985
003obl av	131	50		6	29	3.5	1.3	1.1	1857	1987
003obl av	131	56		5	39	4.8	0.4	1.3	1852	1982
003obl av	131	53		4	23	2.7	0.7	0.9	1858	1988
003obl av	131	51		4	19	2.2	1.4	0.3	1872	2002
003obl av	131	54		3	35	4.3	0.1	0.9	1856	1986
003obl av	131	51		3	28	3.3	0.7	0.4	1862	1992
003obl av	131	51		3	20	2.3	0.8	0.4	1871	2001
003obl av	131	51		2	19	2.2	0.7	0.1	1859	1989
003obl av	131	51		2	31	3.7	0.3	0.3	1850	1980
003obl av	131	44		2	41	5.1	0.5	0.5	1854	1984
003obl av	131	54		1	42	5.2	0.1	0.2	1853	1983
003obl av	131	52		1	20	2.3	0.2	0.2	1870	2000

Sample (=HalfCh): 004ten av	0	77	1926	2002
Reference (=HalfCh): c04obl av	0	155	1848	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
004ten av	77	60	*	18	24	2.2	2.9	3.0	1918	1994
004ten av	77	59		11	6	0.5	1.8	1.8	1926	2002
004ten av	77	51		9	1	0.0	2.1	1.5	1920	1996
004ten av	77	57		8	18	1.6	1.7	1.1	1922	1998
004ten av	77	55		8	14	1.2	2.0	0.9	1910	1986
004ten av	77	53		8	28	2.5	2.0	0.9	1923	1999
004ten av	77	52		8	-6	0.5	1.3	1.7	1914	1990
004ten av	77	54		7	14	1.2	1.3	1.1	1911	1987
004ten av	77	51		7	12	1.1	1.9	0.8	1924	2000
004ten av	74	58		6	6	0.5	1.3	1.0	1929	2005

004ten av	77	52		6	-7	0.6	1.7	0.4	1904	1980
004ten av	77	53		4	-11	0.9	0.7	0.7	1908	1984
004ten av	77	52		4	24	2.1	1.2	0.4	1917	1993
004ten av	77	52		4	5	0.5	0.8	0.7	1916	1992
004ten av	77	58		3	-11	0.9	0.3	0.6	1907	1983
004ten av	77	56		3	9	0.8	0.4	0.7	1913	1989
004ten av	77	55		3	-10	0.8	0.3	0.7	1905	1981

Sample (=HalfCh): 006pul av 0 134 1869 2002
Reference (=HalfCh): c04obl av 0 155 1848 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
006pul av	133	59	*	11	45	5.8	1.3	2.6	1870	2003
006pul av	134	57		11	24	2.9	1.8	1.9	1852	1985
006pul av	132	52		11	39	4.8	1.9	2.3	1871	2004
006pul av	134	55		8	34	4.1	0.9	2.0	1864	1997
006pul av	133	54		8	20	2.3	1.7	1.3	1847	1980
006pul av	134	53		8	22	2.6	2.0	0.9	1848	1981
006pul av	134	52		7	19	2.2	1.0	1.8	1853	1986
006pul av	134	52		5	38	4.7	0.8	1.0	1868	2001
006pul av	134	55		4	29	3.4	0.3	1.0	1863	1996
006pul av	134	54		3	21	2.5	0.5	0.5	1858	1991
006pul av	134	52		3	21	2.5	0.9	0.3	1854	1987
006pul av	134	55		2	19	2.3	0.7	0.2	1849	1982
006pul av	134	51		2	43	5.5	0.7	0.1	1869	2002
006pul av	134	55		1	23	2.7	0.1	0.4	1855	1988
006pul av	134	53		1	24	2.8	0.4	0.1	1857	1990

Sample (=HalfCh): 007ten av 0 94 1910 2003
Reference (=HalfCh): c04obl av 0 155 1848 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
007ten av	92	34		13	-4	0.4	3.1	4.6	1911	2004
007ten av	93	57		11	13	1.3	1.2	2.6	1910	2003
007ten av	94	55		8	25	2.5	1.6	1.2	1906	1999
007ten av	94	54		8	4	0.4	1.4	1.5	1889	1982
007ten av	94	51		8	27	2.7	2.6	0.4	1909	2002
007ten av	94	59	*	7	33	3.4	1.5	0.7	1903	1996
007ten av	91	53		5	6	0.6	0.2	1.7	1912	2005
007ten av	94	53		5	25	2.5	1.3	0.6	1904	1997
007ten av	94	51		4	12	1.1	0.6	0.9	1890	1983
007ten av	94	54		3	14	1.3	1.2	0.1	1887	1980
007ten av	90	56		2	15	1.4	0.6	0.0	1913	2006
007ten av	94	56		2	20	2.0	0.2	0.4	1892	1985
007ten av	94	56		2	25	2.5	0.2	0.4	1897	1990
007ten av	94	53		2	8	0.7	0.3	0.5	1888	1981
007ten av	94	52		2	19	1.9	0.3	0.6	1893	1986
007ten av	94	60	*	1	28	2.8	0.0	0.2	1899	1992
007ten av	94	54		1	24	2.3	0.2	0.1	1907	2000
007ten av	94	55		0	20	1.9	0.1	0.0	1895	1988
007ten av	94	54		0	26	2.6	0.0	0.1	1898	1991

Sample (=HalfCh): 008ten av 0 99 1904 2002
Reference (=HalfCh): c04obl av 0 155 1848 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
008ten av	99	57		10	-13	1.3	2.3	1.0	1887	1985
008ten av	99	59	*	9	-28	2.9	0.8	2.3	1897	1995
008ten av	99	55		7	-22	2.2	1.1	1.4	1901	1999
008ten av	99	61	*	6	-36	3.8	1.4	0.4	1891	1989
008ten av	99	60	*	6	-23	2.3	0.3	1.7	1899	1997
008ten av	96	56		4	-6	0.6	0.9	0.7	1907	2005
008ten av	99	57		3	-12	1.2	0.9	0.1	1885	1983
008ten av	97	51		3	-10	1.0	0.6	0.4	1906	2004
008ten av	99	56		1	-2	0.2	0.2	0.1	1882	1980
008ten av	99	54		1	-13	1.3	0.0	0.2	1886	1984
008ten av	99	52		1	-11	1.1	0.2	0.0	1883	1981
008ten av	99	51		1	-17	1.7	0.4	0.1	1903	2001
008ten av	95	51		1	-11	1.1	0.4	0.1	1908	2006
008ten av	99	53		0	-35	3.7	0.2	0.0	1895	1993

Sample	(=HalfCh):	009ten av	0	74	1929	2002
Reference	(=HalfCh):	c04obl av	0	155	1848	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
009ten av	71	60	*	15	10	0.9	3.0	2.0	1932	2005
009ten av	74	65	**	12	-4	0.3	1.9	1.9	1910	1983
009ten av	73	49		11	-15	1.3	2.7	1.8	1930	2003
009ten av	74	55		10	9	0.8	2.1	1.4	1928	2001
009ten av	74	55		7	-35	3.2	1.4	1.0	1914	1987
009ten av	74	60	*	4	4	0.4	0.2	1.2	1926	1999
009ten av	74	59		4	-4	0.3	0.4	0.9	1922	1995
009ten av	74	53		3	-5	0.4	0.8	0.5	1921	1994
009ten av	74	53		3	4	0.3	0.7	0.4	1908	1981
009ten av	74	59		2	-26	2.2	0.5	0.0	1917	1990
009ten av	74	53		2	-4	0.4	0.6	0.2	1924	1997
009ten av	74	52		2	-15	1.3	0.4	0.3	1920	1993
009ten av	74	51		2	0	0.0	0.5	0.2	1909	1982
009ten av	74	51		2	8	0.7	0.2	0.5	1927	2000
009ten av	74	52		1	-8	0.7	0.1	0.3	1923	1996

Sample	(=HalfCh):	c04obl av	0	155	1848	2002
Reference	(=HalfCh):	c04obl av	0	155	1848	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c04obl av	155	100	***	1000	100	100.0	100.0	100.0	1848	2002
c04obl av	153	46		17	53	7.7	6.4	1.0	1846	2000
c04obl av	153	46		17	53	7.7	6.4	1.0	1850	2004
c04obl av	133	58	*	14	2	0.2	3.2	1.8	1826	1980
c04obl av	137	54		12	12	1.5	2.8	1.8	1830	1984
c04obl av	135	52		12	-6	0.7	3.4	1.4	1828	1982
c04obl av	152	52		8	44	6.0	1.8	1.2	1845	1999
c04obl av	152	52		8	44	6.0	1.8	1.2	1851	2005
c04obl av	144	51		8	10	1.2	1.6	1.7	1837	1991
c04obl av	139	52		5	13	1.5	1.6	0.5	1832	1986
c04obl av	145	52		5	12	1.4	0.1	1.7	1838	1992
c04obl av	150	54		4	41	5.4	1.1	0.3	1843	1997
c04obl av	147	51		4	19	2.3	1.4	0.3	1840	1994
c04obl av	141	52		3	7	0.9	1.1	0.2	1834	1988

```
c04obl av   154  49         3   75  13.8    0.8    0.3   1847   2001
c04obl av   154  49         3   75  13.8    0.8    0.3   1849   2003
c04obl av   149  55         2   32   4.1    0.4    0.3   1842   1996
c04obl av   138  54         2   15   1.8    0.5    0.2   1831   1985
c04obl av   151  50         2   43   5.8    0.5    0.2   1844   1998
c04obl av   151  50         2   43   5.8    0.5    0.2   1852   2006
c04obl av   140  54         1   11   1.3    0.2    0.4   1833   1987
-----------------------------------------------------------------

Sample    (=HalfCh): c06pul av                          0      130  1873  2002
Reference (=HalfCh): c04obl av                          0      155  1848  2002

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
c06pul av   130  57         9   13   1.4    1.9    1.3   1869   1998
c06pul av   130  57 *       6    2   0.3    0.8    1.3   1859   1988
c06pul av   129  53         5   14   1.5    1.1    0.7   1874   2003
c06pul av   126  51         5   21   2.4    0.7    1.1   1877   2006
c06pul av   130  58 *       4   -5   0.6    0.3    1.0   1851   1980
c06pul av   130  52         4   -2   0.2    0.6    1.0   1853   1982
c06pul av   130  51         4   -2   0.2    0.7    0.8   1863   1992
c06pul av   130  50         4   -6   0.6    1.1    0.5   1864   1993
c06pul av   130  54         2   -2   0.3    0.8    0.1   1862   1991
c06pul av   130  54         1    2   0.2    0.0    0.4   1866   1995
c06pul av   130  54         1    0   0.0    0.1    0.2   1865   1994
-----------------------------------------------------------------

Sample    (=HalfCh): c07obl av                          0      114  1889  2002
Reference (=HalfCh): c04obl av                          0      155  1848  2002

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
c07obl av   110  55        10    3   0.3    1.4    2.2   1893   2006
c07obl av   114  50        10   -1   0.1    1.8    2.1   1882   1995
c07obl av   114  54         8   18   2.0    1.2    1.7   1870   1983
c07obl av   114  54         5   22   2.4    0.7    1.2   1872   1985
c07obl av   114  53         5   -8   0.9    1.2    0.8   1884   1997
c07obl av   111  52         5   -1   0.2    0.9    1.0   1892   2005
c07obl av   114  52         5   -8   0.9    0.7    1.2   1889   2002
c07obl av   114  51         5   22   2.4    0.4    1.4   1869   1982
c07obl av   114  53         4   18   1.9    0.9    0.7   1878   1991
c07obl av   114  52         4   13   1.4    0.6    0.9   1879   1992
c07obl av   114  50         4   21   2.3    1.0    0.4   1873   1986
c07obl av   114  52         3   17   1.8    1.1    0.2   1876   1989
c07obl av   114  51         3    7   0.7    1.1    0.2   1880   1993
c07obl av   114  59 *       1   -6   0.7    0.0    0.2   1885   1998
c07obl av   114  54         1  -12   1.3    0.0    0.3   1887   2000
c07obl av   114  52         1   -6   0.6    0.2    0.3   1883   1996
-----------------------------------------------------------------

Sample    (=HalfCh): c08ten av                          0       93  1910  2002
Reference (=HalfCh): c04obl av                          0      155  1848  2002

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
c08ten av    93  55        17   28   2.8    3.3    3.0   1910   2002
c08ten av    93  57         9   32   3.3    2.0    1.1   1904   1996
c08ten av    93  54         8    3   0.2    1.4    1.4   1890   1982
c08ten av    93  57         7   25   2.4    1.4    1.2   1907   1999
c08ten av    93  55         7   23   2.3    1.7    0.9   1905   1997
```

c08ten av	92	59	*	6	10	1.0	0.3	1.7	1911	2003
c08ten av	93	59	*	4	27	2.7	0.1	1.1	1900	1992
c08ten av	93	54		4	14	1.3	1.1	0.3	1888	1980
c08ten av	93	53		3	8	0.7	0.5	0.6	1889	1981
c08ten av	90	51		3	1	0.1	0.9	0.2	1913	2005
c08ten av	93	56		2	20	2.0	0.4	0.4	1893	1985
c08ten av	89	54		2	16	1.5	0.7	0.2	1914	2006
c08ten av	93	52		2	23	2.2	0.7	0.0	1908	2000
c08ten av	93	54		1	27	2.6	0.3	0.2	1899	1991
c08ten av	93	54		1	19	1.9	0.2	0.0	1896	1988
c08ten av	93	52		1	25	2.4	0.3	0.0	1898	1990
c08ten av	93	51		1	15	1.5	0.1	0.2	1892	1984

Sample	(=HalfCh): c12ten av	0	138	1867	2004
Reference	(=HalfCh): c06pul av	0	130	1873	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c12ten av	130	46		11	-5	0.6	2.2	2.4	1865	2002
c12ten av	130	54		8	3	0.4	1.2	1.7	1866	2003
c12ten av	130	52		7	3	0.3	1.5	1.0	1869	2006
c12ten av	122	57		5	32	3.7	1.2	0.7	1857	1994
c12ten av	124	54		5	18	2.0	0.2	1.6	1859	1996
c12ten av	120	50		5	19	2.1	1.4	0.9	1855	1992
c12ten av	130	52		4	4	0.5	1.1	0.3	1867	2004
c12ten av	109	55		3	12	1.3	1.1	0.0	1844	1981
c12ten av	114	54		3	12	1.3	0.6	0.5	1849	1986
c12ten av	112	55		2	10	1.0	0.1	0.5	1847	1984
c12ten av	126	54		2	5	0.6	0.5	0.2	1861	1998
c12ten av	117	51		2	14	1.5	0.5	0.5	1852	1989
c12ten av	121	50		2	24	2.7	0.2	0.5	1856	1993
c12ten av	110	54		1	16	1.7	0.4	0.0	1845	1982
c12ten av	116	51		1	10	1.1	0.3	0.1	1851	1988
c12ten av	108	50		1	22	2.3	0.1	0.2	1843	1980

Sample	(=HalfCh): 003Aobl av	0	122	1881	2002
Reference	(=HalfCh): c06pul av	0	130	1873	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003Aobl av	122	53		12	17	1.9	2.2	2.2	1881	2002
003Aobl av	122	55		7	27	3.1	1.6	1.1	1876	1997
003Aobl av	122	51		7	16	1.8	2.0	0.8	1875	1996
003Aobl av	120	55		6	15	1.7	1.6	0.5	1883	2004
003Aobl av	122	53		6	23	2.6	0.6	1.6	1879	2000
003Aobl av	118	55		5	23	2.5	1.2	0.8	1869	1990
003Aobl av	108	58		4	23	2.4	1.0	0.5	1859	1980
003Aobl av	110	55		3	21	2.2	0.8	0.5	1861	1982
003Aobl av	122	54		3	20	2.2	0.9	0.2	1873	1994
003Aobl av	116	51		3	26	2.9	0.7	0.6	1867	1988
003Aobl av	113	57		2	21	2.3	0.1	0.4	1864	1985
003Aobl av	120	56		2	19	2.1	0.3	0.3	1871	1992
003Aobl av	122	53		2	22	2.5	0.6	0.1	1877	1998
003Aobl av	122	50		2	19	2.1	0.5	0.3	1874	1995
003Aobl av	118	57		1	28	3.1	0.2	0.1	1885	2006
003Aobl av	115	57		1	25	2.7	0.4	0.1	1866	1987

```
Sample    (=HalfCh): 003obl av                    0      131  1872  2002
Reference (=HalfCh): c06pul av                    0      130  1873  2002

  Sample    OVL Glk GSL    CDI  %CC    TV  TVBP  TVH   DateL  DateR
003obl av   129  58 *      14   18   2.1   1.7   3.2   1874   2004
003obl av   128  60 *      12   12   1.4   1.7   2.4   1870   2000
003obl av   127  56        11   10   1.1   1.6   2.5   1876   2006
003obl av   128  47        10    2   0.2   1.7   2.5   1875   2005
003obl av   108  55         5   32   3.5   1.1   0.9   1850   1980
003obl av   130  51         4   10   1.2   0.8   0.7   1872   2002
003obl av   115  50         4   24   2.6   0.9   0.9   1857   1987
003obl av   109  50         4   29   3.2   1.4   0.6   1851   1981
003obl av   120  59 *       3   15   1.6   0.3   0.6   1862   1992
003obl av   125  52         3   12   1.3   0.9   0.1   1867   1997
003obl av   112  57         2   17   1.8   0.2   0.4   1854   1984
003obl av   122  50         2    2   0.3   0.3   0.7   1864   1994
003obl av   124  55         1    5   0.5   0.0   0.3   1866   1996
003obl av   116  53         1   20   2.1   0.2   0.2   1858   1988
-----------------------------------------------------------------

Sample    (=HalfCh): 004ten av                    0       77  1926  2002
Reference (=HalfCh): c06pul av                    0      130  1873  2002

  Sample    OVL Glk GSL    CDI  %CC    TV  TVBP  TVH   DateL  DateR
004ten av    77  52        13  -19   1.7   2.6   2.6   1904   1980
004ten av    77  59        12    5   0.5   1.7   2.4   1912   1988
004ten av    73  46        10  -20   1.7   2.8   1.6   1930   2006
004ten av    77  60 *       8   19   1.6   1.4   1.4   1916   1992
004ten av    77  57         8    8   0.7   1.7   1.3   1925   2001
004ten av    76  53         6   -8   0.7   1.0   1.2   1927   2003
004ten av    77  51         6    8   0.7   1.2   1.1   1909   1985
004ten av    77  55         5    0   0.0   1.0   0.7   1908   1984
004ten av    77  61 *       4    2   0.2   0.1   1.2   1914   1990
004ten av    77  52         4   -3   0.3   0.8   0.9   1919   1995
004ten av    74  55         2   -3   0.3   0.5   0.1   1929   2005
004ten av    77  53         2    6   0.5   0.5   0.2   1922   1998
004ten av    77  56         1   -1   0.1   0.1   0.2   1910   1986
004ten av    77  53         1    0   0.0   0.3   0.1   1921   1997
004ten av    77  53         1    6   0.5   0.1   0.2   1923   1999
004ten av    77  51         1    9   0.8   0.2   0.3   1917   1993
-----------------------------------------------------------------

Sample    (=HalfCh): 006pul av                    0      134  1869  2002
Reference (=HalfCh): c06pul av                    0      130  1873  2002

  Sample    OVL Glk GSL    CDI  %CC    TV  TVBP  TVH   DateL  DateR
006pul av   127  63 **     17   37   4.4   2.6   2.8   1866   1999
006pul av   128  44        11   20   2.3   2.4   2.6   1867   2000
006pul av   121  60 *       7   25   2.8   1.2   1.2   1860   1993
006pul av   130  54         6   19   2.2   1.5   0.8   1872   2005
006pul av   125  54         5   31   3.6   0.7   1.1   1864   1997
006pul av   116  53         5   21   2.2   0.9   1.1   1855   1988
006pul av   108  55         4   17   1.8   1.0   0.5   1847   1980
006pul av   130  54         3   21   2.4   0.8   0.4   1871   2004
006pul av   110  51         3   23   2.4   0.4   0.8   1849   1982
006pul av   124  50         3   31   3.6   0.4   1.0   1863   1996
```

006pul av	129	54		2	25	2.9	0.1	0.6	1868	2001
006pul av	111	53		2	20	2.2	0.6	0.2	1850	1983
006pul av	112	50		1	27	2.9	0.1	0.3	1851	1984
006pul av	115	50		1	20	2.2	0.4	0.2	1854	1987
006pul av	119	55		0	24	2.7	0.1	0.0	1858	1991

Sample (=HalfCh): 007ten av 0 94 1910 2003
Reference (=HalfCh): c06pul av 0 130 1873 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
007ten av	94	63	**	16	40	4.2	2.3	2.8	1887	1980
007ten av	94	56		8	-3	0.3	1.5	1.3	1906	1999
007ten av	94	52		8	8	0.8	1.8	1.3	1896	1989
007ten av	94	53		6	-8	0.8	1.4	1.0	1909	2002
007ten av	94	52		6	33	3.3	0.9	1.6	1889	1982
007ten av	94	51		6	21	2.1	1.5	0.8	1897	1990
007ten av	94	59	*	5	21	2.0	1.0	0.7	1898	1991
007ten av	94	57		4	17	1.7	1.0	0.4	1891	1984
007ten av	94	55		4	16	1.5	0.6	1.0	1900	1993
007ten av	94	54		3	4	0.3	0.1	0.8	1904	1997
007ten av	94	54		3	21	2.1	0.4	0.7	1893	1986
007ten av	94	54		3	5	0.5	0.4	0.7	1902	1995
007ten av	90	51		3	0	0.0	0.6	0.4	1913	2006
007ten av	94	51		3	-1	0.1	0.8	0.3	1903	1996
007ten av	94	58		2	-13	1.2	0.5	0.2	1908	2001
007ten av	91	51		2	-4	0.4	0.5	0.5	1912	2005
007ten av	93	51		2	-13	1.3	0.4	0.3	1910	2003

Sample (=HalfCh): 008ten av 0 99 1904 2002
Reference (=HalfCh): c06pul av 0 130 1873 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
008ten av	99	57		9	10	1.0	1.7	1.4	1891	1989
008ten av	99	56		7	-8	0.7	1.6	0.9	1885	1983
008ten av	99	53		7	10	1.0	0.9	1.7	1904	2002
008ten av	99	59	*	6	-1	0.1	1.2	1.0	1896	1994
008ten av	97	53		5	16	1.5	0.6	1.1	1906	2004
008ten av	99	52		4	0	0.0	0.5	1.2	1898	1996
008ten av	99	52		3	-10	1.0	0.9	0.4	1889	1987
008ten av	99	58		2	2	0.2	0.2	0.6	1893	1991
008ten av	99	57		2	-17	1.7	0.6	0.1	1883	1981
008ten av	99	51		2	-10	1.0	0.2	0.5	1887	1985
008ten av	99	51		2	-16	1.6	0.1	0.8	1886	1984
008ten av	99	52		1	3	0.3	0.1	0.4	1900	1998
008ten av	99	51		1	-1	0.1	0.2	0.2	1890	1988
008ten av	99	51		0	-1	0.1	0.1	0.0	1894	1992

Sample (=HalfCh): 009ten av 0 74 1929 2002
Reference (=HalfCh): c06pul av 0 130 1873 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
009ten av	74	53		10	8	0.7	1.9	1.9	1928	2001
009ten av	71	70	***	9	-12	1.0	1.2	1.3	1932	2005
009ten av	74	53		9	17	1.5	1.1	2.1	1921	1994

```
009ten av    74  58          7   16   1.4    1.4    1.1    1924     1997
009ten av    74  55          7   -1   0.1    1.3    1.2    1912     1985
009ten av    74  58          5   -8   0.7    1.5    0.4    1926     1999
009ten av    73  54          5   -7   0.6    1.4    0.6    1930     2003
009ten av    74  53          5  -19   1.7    0.8    0.9    1915     1988
009ten av    74  53          5   -9   0.7    0.8    1.1    1916     1989
009ten av    74  52          5   -4   0.3    0.9    0.9    1918     1991
009ten av    74  51          4  -13   1.1    0.9    0.7    1914     1987
009ten av    74  65 **       2   -9   0.7    0.0    0.6    1910     1983
009ten av    74  56          2    4   0.3    0.5    0.1    1908     1981
-----------------------------------------------------------------

Sample    (=HalfCh): c04obl av                          0       155  1848   2002
Reference (=HalfCh): c06pul av                          0       130  1873   2002

  Sample    OVL Glk GSL   CDI  %CC     TV  TVBP  TVH   DateL  DateR
c04obl av   130  57          9   13   1.4    1.9    1.3    1852     2006
c04obl av   120  58 *        7   12   1.3    1.4    1.0    1838     1992
c04obl av   129  53          5   14   1.5    1.1    0.7    1847     2001
c04obl av   126  51          5   21   2.4    0.7    1.1    1844     1998
c04obl av   114  55          3   19   2.0    0.3    0.9    1832     1986
c04obl av   108  51          3   25   2.7    0.8    0.3    1826     1980
c04obl av   118  57          2    8   0.8    0.1    0.5    1836     1990
c04obl av   125  54          2   23   2.6    0.6    0.1    1843     1997
c04obl av   110  50          2   26   2.8    0.3    0.7    1828     1982
c04obl av   122  55          1    9   1.0    0.0    0.2    1840     1994
c04obl av   116  53          1   15   1.6    0.0    0.5    1834     1988
c04obl av   124  52          1   11   1.3    0.3    0.2    1842     1996
c04obl av   109  51          1   25   2.7    0.4    0.0    1827     1981
c04obl av   115  50          1   16   1.7    0.4    0.1    1833     1987
-----------------------------------------------------------------

Sample    (=HalfCh): c06pul av                          0       130  1873   2002
Reference (=HalfCh): c06pul av                          0       130  1873   2002

  Sample    OVL Glk GSL   CDI  %CC     TV  TVBP  TVH   DateL  DateR
c06pul av   130 100 ***  1000  100 100.0  100.0  100.0    1873     2002
c06pul av   129  33         15   29   3.5    2.9    6.1    1872     2001
c06pul av   129  33         15   29   3.5    2.9    6.1    1874     2003
c06pul av   119  56         14   19   2.1    2.2    2.9    1862     1991
c06pul av   128  62 **      13   36   4.3    2.1    2.0    1871     2000
c06pul av   128  62 **      13   36   4.3    2.1    2.0    1875     2004
c06pul av   114  61 *       12   13   1.4    2.4    1.9    1857     1986
c06pul av   121  55          6   24   2.6    0.7    1.4    1864     1993
c06pul av   116  51          6   -6   0.6    1.6    0.8    1859     1988
c06pul av   111  53          4   15   1.6    0.8    0.8    1854     1983
c06pul av   108  50          3    7   0.8    1.0    0.4    1851     1980
c06pul av   125  54          2    7   0.7    0.5    0.2    1868     1997
c06pul av   126  54          2    7   0.8    0.2    0.3    1869     1998
c06pul av   126  54          2    7   0.8    0.2    0.3    1877     2006
c06pul av   123  52          2   14   1.6    0.2    0.6    1866     1995
c06pul av   112  51          2   14   1.5    0.1    0.7    1855     1984
c06pul av   109  52          0    9   0.9    0.1    0.1    1852     1981
-----------------------------------------------------------------

Sample    (=HalfCh): c07obl av                          0       114  1889   2002
Reference (=HalfCh): c06pul av                          0       130  1873   2002
```

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c07obl av	111	62	**	11	15	1.5	2.0	1.6	1892	2005
c07obl av	114	60	*	8	9	1.0	0.9	1.7	1887	2000
c07obl av	114	57		8	21	2.3	1.1	1.8	1881	1994
c07obl av	109	53		8	36	4.0	1.2	1.9	1868	1981
c07obl av	114	54		7	8	0.8	0.9	1.7	1889	2002
c07obl av	114	59	*	6	16	1.8	0.6	1.6	1883	1996
c07obl av	114	54		5	29	3.2	0.9	0.9	1875	1988
c07obl av	114	53		4	7	0.8	0.9	0.5	1886	1999
c07obl av	114	54		3	9	1.0	0.2	0.8	1885	1998
c07obl av	114	51		3	15	1.6	0.3	0.7	1880	1993
c07obl av	114	51		3	34	3.8	0.8	0.6	1873	1986
c07obl av	111	55		2	30	3.2	0.2	0.7	1870	1983
c07obl av	108	51		2	30	3.2	0.7	0.0	1867	1980
c07obl av	114	58		1	18	1.9	0.5	0.0	1879	1992
c07obl av	114	51		1	20	2.2	0.4	0.0	1877	1990

Sample (=HalfCh): c08ten av 0 93 1910 2002
Reference (=HalfCh): c06pul av 0 130 1873 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c08ten av	93	57		9	37	3.9	1.8	1.5	1888	1980
c08ten av	93	52		7	6	0.6	1.8	0.8	1897	1989
c08ten av	93	56		6	15	1.4	1.3	0.7	1892	1984
c08ten av	93	56		6	17	1.7	0.7	1.4	1901	1993
c08ten av	90	55		5	-4	0.4	0.8	0.9	1913	2005
c08ten av	93	52		5	16	1.5	0.9	1.0	1895	1987
c08ten av	93	52		5	31	3.1	0.8	1.1	1890	1982
c08ten av	93	59	*	4	21	2.1	1.2	0.0	1894	1986
c08ten av	93	53		4	-8	0.8	1.3	0.3	1910	2002
c08ten av	93	58		3	21	2.0	0.7	0.2	1899	1991
c08ten av	93	58		3	7	0.6	0.3	0.8	1903	1995
c08ten av	89	53		3	-3	0.3	0.8	0.5	1914	2006
c08ten av	93	51		3	3	0.3	0.3	0.7	1905	1997
c08ten av	93	52		1	-15	1.4	0.4	0.1	1909	2001
c08ten av	92	52		1	-11	1.0	0.0	0.5	1911	2003

Sample (=HalfCh): c12ten av 0 138 1867 2004
Reference (=HalfCh): c07obl av 0 114 1889 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c12ten av	107	55		7	9	0.9	1.2	1.4	1858	1995
c12ten av	97	57		6	-8	0.8	0.8	1.5	1848	1985
c12ten av	114	56		5	23	2.5	1.0	0.7	1866	2003
c12ten av	110	54		5	25	2.6	1.1	0.7	1861	1998
c12ten av	112	50		5	29	3.1	1.2	0.6	1863	2000
c12ten av	108	50		4	21	2.2	0.8	1.0	1859	1996
c12ten av	95	52		3	-28	2.8	0.2	0.8	1846	1983
c12ten av	114	50		3	14	1.5	0.8	0.4	1865	2002
c12ten av	100	52		2	7	0.7	0.4	0.3	1851	1988
c12ten av	113	50		2	18	1.9	0.7	0.0	1864	2001
c12ten av	103	55		1	9	0.9	0.2	0.3	1854	1991
c12ten av	114	55		1	22	2.4	0.1	0.3	1868	2005
c12ten av	99	54		1	5	0.5	0.2	0.0	1850	1987

Sample (=HalfCh): 003Aobl av 0 122 1881 2002
Reference (=HalfCh): c07obl av 0 114 1889 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003Aobl av	106	60	*	7	46	5.3	1.4	1.1	1873	1994
003Aobl av	92	58		7	30	3.0	1.7	1.1	1859	1980
003Aobl av	111	57		6	26	2.8	1.0	1.1	1878	1999
003Aobl av	96	55		6	48	5.3	0.8	1.4	1863	1984
003Aobl av	102	53		5	43	4.8	1.2	0.6	1869	1990
003Aobl av	103	50		5	39	4.3	1.1	1.1	1870	1991
003Aobl av	99	54		4	36	3.8	1.2	0.4	1866	1987
003Aobl av	94	51		4	39	4.1	1.2	0.4	1861	1982
003Aobl av	104	56		3	43	4.8	1.0	0.2	1871	1992
003Aobl av	107	54		3	41	4.6	0.8	0.5	1874	1995
003Aobl av	95	53		3	42	4.5	0.5	0.6	1862	1983
003Aobl av	114	52		2	19	2.0	0.4	0.2	1882	2003
003Aobl av	114	50		2	21	2.3	0.5	0.3	1883	2004
003Aobl av	97	56		1	48	5.3	0.3	0.1	1864	1985
003Aobl av	114	54		1	22	2.4	0.1	0.2	1885	2006
003Aobl av	109	50		1	35	3.8	0.2	0.3	1876	1997
003Aobl av	114	53		0	15	1.6	0.1	0.0	1881	2002

Sample (=HalfCh): 003obl av 0 131 1872 2002
Reference (=HalfCh): c07obl av 0 114 1889 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003obl av	103	62	**	14	32	3.4	2.2	2.6	1861	1991
003obl av	109	56		14	35	3.8	2.8	2.2	1867	1997
003obl av	94	57		10	35	3.5	1.8	1.9	1852	1982
003obl av	111	49		10	16	1.7	2.0	2.0	1869	1999
003obl av	114	51		8	38	4.3	1.9	1.3	1873	2003
003obl av	96	57		7	25	2.5	1.0	1.8	1854	1984
003obl av	114	52		7	35	4.0	1.3	1.3	1875	2005
003obl av	114	56		6	21	2.2	1.3	0.9	1872	2002
003obl av	114	52		6	39	4.5	1.2	1.1	1874	2004
003obl av	106	53		5	40	4.5	1.5	0.5	1864	1994
003obl av	113	51		5	19	2.1	1.0	1.0	1871	2001
003obl av	101	51		5	23	2.3	1.3	0.7	1859	1989
003obl av	114	55		4	35	4.0	0.3	1.3	1876	2006
003obl av	97	51		4	14	1.4	0.7	1.2	1855	1985
003obl av	98	51		4	15	1.4	1.1	0.6	1856	1986
003obl av	107	52		3	35	3.9	0.9	0.2	1865	1995
003obl av	99	51		2	22	2.2	0.9	0.0	1857	1987
003obl av	100	51		2	18	1.9	0.5	0.1	1858	1988
003obl av	93	50		2	38	3.9	0.5	0.2	1851	1981

Sample (=HalfCh): 004ten av 0 77 1926 2002
Reference (=HalfCh): c07obl av 0 114 1889 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
004ten av	77	66	**	21	-15	1.3	3.3	3.0	1907	1983
004ten av	77	59		13	-3	0.3	2.3	2.2	1922	1998
004ten av	77	58		13	16	1.4	2.4	2.2	1926	2002

004ten av	77	60	*	10	-23	2.0	1.7	1.7	1913	1989
004ten av	77	50		10	-13	1.2	2.5	1.5	1924	2000
004ten av	77	55		6	-14	1.3	0.4	1.9	1920	1996
004ten av	77	57		5	-28	2.5	0.6	1.1	1916	1992
004ten av	77	53		5	-17	1.5	1.5	0.4	1905	1981
004ten av	77	50		5	-39	3.7	1.5	0.6	1909	1985
004ten av	77	61	*	4	-27	2.4	0.3	0.9	1918	1994
004ten av	77	58		4	-35	3.2	0.5	0.8	1911	1987
004ten av	77	53		4	-15	1.4	0.3	1.1	1904	1980
004ten av	75	55		3	18	1.5	0.2	0.7	1928	2004
004ten av	73	54		2	2	0.2	0.5	0.2	1930	2006
004ten av	77	51		1	-14	1.2	0.4	0.0	1906	1982

Sample	(=HalfCh):	006pul av	0	134	1869	2002
Reference	(=HalfCh):	c07obl av	0	114	1889	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
006pul av	114	58	*	13	14	1.5	2.0	2.3	1872	2005
006pul av	113	59	*	11	8	0.9	2.1	1.8	1868	2001
006pul av	101	40		10	-6	0.6	3.1	2.3	1856	1989
006pul av	99	50		9	-2	0.2	2.2	1.6	1854	1987
006pul av	114	52		7	2	0.2	1.8	0.8	1870	2003
006pul av	106	51		7	15	1.6	1.4	1.4	1861	1994
006pul av	109	50		7	17	1.8	1.5	1.3	1864	1997
006pul av	112	53		6	8	0.8	0.9	1.3	1867	2000
006pul av	102	60	*	4	1	0.1	0.4	0.9	1857	1990
006pul av	92	52		4	-4	0.4	0.5	1.1	1847	1980
006pul av	110	56		3	16	1.7	0.2	1.0	1865	1998
006pul av	105	56		2	17	1.7	0.3	0.6	1860	1993
006pul av	95	55		2	-11	1.1	0.5	0.4	1850	1983
006pul av	93	54		1	-2	0.2	0.1	0.5	1848	1981
006pul av	108	54		1	18	1.9	0.3	0.1	1863	1996
006pul av	100	54		1	-4	0.4	0.1	0.2	1855	1988

Sample	(=HalfCh):	007ten av	0	94	1910	2003
Reference	(=HalfCh):	c07obl av	0	114	1889	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
007ten av	94	57		11	11	1.0	2.1	1.9	1903	1996
007ten av	94	58		8	29	3.0	0.7	2.0	1908	2001
007ten av	90	53		8	37	3.7	1.8	1.3	1913	2006
007ten av	93	51		8	48	5.2	1.3	1.7	1910	2003
007ten av	94	54		7	9	0.9	1.3	1.2	1894	1987
007ten av	94	59	*	6	16	1.6	0.4	1.8	1906	1999
007ten av	94	54		6	18	1.8	1.0	1.3	1889	1982
007ten av	94	53		5	3	0.3	0.3	1.4	1897	1990
007ten av	92	50		4	5	0.5	0.7	0.9	1887	1980
007ten av	92	46		4	47	5.0	0.9	0.8	1911	2004
007ten av	94	61	*	3	0	0.0	0.7	0.3	1901	1994
007ten av	94	52		3	34	3.5	0.1	1.0	1909	2002
007ten av	93	51		3	15	1.5	0.9	0.2	1888	1981
007ten av	94	58		2	4	0.4	0.5	0.3	1899	1992
007ten av	94	55		2	9	0.8	0.5	0.1	1893	1986
007ten av	91	55		1	41	4.3	0.4	0.1	1912	2005
007ten av	94	55		1	7	0.7	0.1	0.1	1895	1988

Sample (=HalfCh): 008ten av 0 99 1904 2002
Reference (=HalfCh): c07obl av 0 114 1889 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
008ten av	99	64	**	11	-4	0.4	1.3	2.1	1893	1991
008ten av	95	57		11	4	0.4	2.1	1.9	1908	2006
008ten av	93	52		9	-27	2.6	2.5	1.0	1883	1981
008ten av	99	59	*	7	12	1.2	1.4	1.1	1903	2001
008ten av	99	57		7	7	0.7	1.7	0.7	1902	2000
008ten av	99	53		7	6	0.6	1.3	1.5	1897	1995
008ten av	99	52		6	-3	0.3	1.7	0.8	1901	1999
008ten av	97	50		6	-18	1.8	1.8	0.8	1887	1985
008ten av	92	53		5	-37	3.8	1.0	0.9	1882	1980
008ten av	99	50		5	-5	0.5	1.2	0.9	1889	1987
008ten av	99	58		4	-2	0.2	0.3	1.1	1895	1993
008ten av	99	55		4	2	0.2	0.9	0.5	1890	1988
008ten av	96	55		4	-25	2.5	0.9	0.4	1886	1984
008ten av	99	55		3	-2	0.2	0.3	0.9	1896	1994
008ten av	97	55		3	-4	0.4	0.8	0.4	1906	2004
008ten av	98	52		2	-7	0.7	0.2	0.5	1888	1986
008ten av	99	52		2	6	0.6	0.3	0.3	1904	2002
008ten av	98	50		2	2	0.2	0.4	0.4	1905	2003
008ten av	99	51		0	0	0.0	0.0	0.1	1899	1997

Sample (=HalfCh): 009ten av 0 74 1929 2002
Reference (=HalfCh): c07obl av 0 114 1889 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
009ten av	74	61	*	13	37	3.4	2.0	2.1	1921	1994
009ten av	74	56		13	58	6.0	2.9	1.9	1918	1991
009ten av	74	58		6	43	4.1	1.0	1.1	1914	1987
009ten av	74	51		6	17	1.4	0.8	1.4	1908	1981
009ten av	74	64	**	4	43	4.1	1.0	0.2	1919	1992
009ten av	74	53		4	14	1.2	0.2	1.2	1907	1980
009ten av	74	52		3	39	3.6	0.6	0.4	1913	1986
009ten av	74	56		2	13	1.1	0.4	0.1	1924	1997
009ten av	71	55		2	-12	1.0	0.7	0.1	1932	2005
009ten av	74	53		2	51	5.0	0.5	0.3	1917	1990
009ten av	74	53		2	12	1.1	0.2	0.6	1910	1983
009ten av	74	51		2	-2	0.2	0.6	0.3	1926	1999
009ten av	74	56		1	-4	0.4	0.3	0.2	1929	2002
009ten av	74	55		1	34	3.1	0.1	0.3	1912	1985
009ten av	72	51		1	-6	0.5	0.1	0.2	1931	2004
009ten av	74	50		1	-2	0.2	0.2	0.2	1928	2001

Sample (=HalfCh): c04obl av 0 155 1848 2002
Reference (=HalfCh): c07obl av 0 114 1889 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c04obl av	109	46		11	-1	0.1	2.0	2.8	1843	1997
c04obl av	110	55		10	3	0.3	1.4	2.2	1844	1998
c04obl av	104	52		7	6	0.6	1.3	1.4	1838	1992
c04obl av	94	52		7	3	0.2	0.8	2.2	1828	1982

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c04obl av	96	51		6	7	0.7	1.1	1.4	1830	1984
c04obl av	111	52		5	-1	0.2	0.9	1.0	1845	1999
c04obl av	114	52		5	-8	0.9	0.7	1.2	1848	2002
c04obl av	107	50		4	2	0.2	1.3	0.4	1841	1995
c04obl av	108	58	*	3	3	0.3	0.4	0.7	1842	1996
c04obl av	101	56		3	11	1.1	0.7	0.5	1835	1989
c04obl av	93	51		3	0	0.0	0.8	0.7	1827	1981
c04obl av	103	55		2	7	0.7	0.6	0.3	1837	1991
c04obl av	98	51		2	9	0.9	0.2	0.8	1832	1986
c04obl av	114	59	*	1	-6	0.7	0.0	0.2	1852	2006
c04obl av	114	54		1	-12	1.3	0.0	0.3	1850	2004

Sample (=HalfCh): c06pul av 0 130 1873 2002
Reference (=HalfCh): c07obl av 0 114 1889 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c06pul av	92	61	*	12	15	1.4	2.2	2.0	1851	1980
c06pul av	111	62	**	11	15	1.5	2.0	1.6	1870	1999
c06pul av	96	54		9	10	1.0	1.8	1.8	1855	1984
c06pul av	114	60	*	8	9	1.0	0.9	1.7	1875	2004
c06pul av	114	54		7	8	0.8	0.9	1.7	1873	2002
c06pul av	101	53		7	1	0.1	1.2	1.7	1860	1989
c06pul av	98	51		6	2	0.2	1.5	0.9	1857	1986
c06pul av	103	53		5	0	0.0	0.5	1.4	1862	1991
c06pul av	105	53		5	2	0.2	0.8	1.1	1864	1993
c06pul av	94	59	*	4	3	0.3	0.7	0.9	1853	1982
c06pul av	97	56		4	4	0.4	0.7	0.7	1856	1985
c06pul av	114	53		4	7	0.8	0.9	0.5	1876	2005
c06pul av	104	52		4	1	0.1	0.5	0.9	1863	1992
c06pul av	114	54		3	9	1.0	0.2	0.8	1877	2006
c06pul av	99	52		3	-1	0.1	0.4	1.0	1858	1987
c06pul av	100	51		3	-6	0.6	0.5	0.9	1859	1988
c06pul av	108	50		3	11	1.2	0.6	0.4	1867	1996
c06pul av	109	51		2	13	1.4	0.6	0.2	1868	1997
c06pul av	107	54		1	6	0.6	0.2	0.1	1866	1995

Sample (=HalfCh): c07obl av 0 114 1889 2002
Reference (=HalfCh): c07obl av 0 114 1889 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c07obl av	114	100	***	1000	100	100.0	100.0	100.0	1889	2002
c07obl av	112	50		18	66	9.2	5.5	1.6	1887	2000
c07obl av	112	50		18	66	9.2	5.5	1.6	1891	2004
c07obl av	108	53		10	38	4.3	1.7	2.0	1883	1996
c07obl av	113	41		10	77	12.6	2.0	3.2	1890	2003
c07obl av	113	41		10	77	12.6	2.0	3.2	1888	2001
c07obl av	99	54		9	10	0.9	1.8	1.9	1874	1987
c07obl av	97	52		7	-2	0.1	1.7	1.0	1872	1985
c07obl av	107	61	**	6	32	3.5	1.4	0.5	1882	1995
c07obl av	101	56		5	19	1.9	0.7	1.1	1876	1989
c07obl av	110	56		5	47	5.5	0.8	0.8	1885	1998
c07obl av	110	56		5	47	5.5	0.8	0.8	1893	2006
c07obl av	95	54		5	0	0.0	0.9	1.2	1870	1983
c07obl av	111	56		4	56	7.0	1.3	0.3	1892	2005
c07obl av	111	56		4	56	7.0	1.3	0.3	1886	1999

c07obl av	94	52		4	3	0.3	0.8	0.8	1869	1982
c07obl av	104	54		2	14	1.5	0.7	0.1	1879	1992
c07obl av	103	50		2	11	1.1	0.4	0.2	1878	1991

Sample (=HalfCh): c08ten av 0 93 1910 2002
Reference (=HalfCh): c07obl av 0 114 1889 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c08ten av	93	55		11	11	1.0	1.6	2.5	1897	1989
c08ten av	93	54		10	16	1.6	1.6	2.2	1891	1983
c08ten av	93	44		10	6	0.6	2.3	2.2	1893	1985
c08ten av	93	57		8	11	1.0	1.4	1.3	1904	1996
c08ten av	93	59	*	7	8	0.7	1.2	1.0	1894	1986
c08ten av	93	58		7	29	2.9	0.9	1.4	1909	2001
c08ten av	93	55		7	7	0.7	0.9	1.9	1896	1988
c08ten av	93	58		5	-2	0.1	1.1	0.8	1902	1994
c08ten av	92	49		5	47	5.1	1.0	1.2	1911	2003
c08ten av	93	58		3	15	1.4	0.4	0.5	1907	1999
c08ten av	93	57		3	3	0.3	0.6	0.3	1900	1992
c08ten av	93	52		3	2	0.2	0.4	0.8	1898	1990
c08ten av	93	51		3	16	1.5	0.3	0.7	1890	1982
c08ten av	90	55		2	40	4.1	0.1	0.5	1913	2005
c08ten av	93	52		2	34	3.5	0.1	0.7	1910	2002
c08ten av	93	51		2	9	0.9	0.1	0.6	1905	1997
c08ten av	93	52		1	14	1.4	0.4	0.1	1889	1981

Sample (=HalfCh): c12ten av 0 138 1867 2004
Reference (=HalfCh): c08ten av 0 93 1910 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c12ten av	93	55		10	18	1.7	1.9	1.7	1869	2006
c12ten av	84	55		10	-7	0.6	2.3	1.5	1856	1993
c12ten av	89	53		8	6	0.5	2.1	1.0	1861	1998
c12ten av	82	57		7	9	0.8	1.7	1.0	1854	1991
c12ten av	71	60	*	4	-24	2.0	1.0	0.4	1843	1980
c12ten av	87	50		4	6	0.6	1.3	0.4	1859	1996
c12ten av	93	55		3	12	1.1	0.1	0.8	1866	2003
c12ten av	92	53		3	6	0.6	0.8	0.4	1864	2001
c12ten av	85	51		3	2	0.2	0.5	0.5	1857	1994
c12ten av	93	51		2	10	0.9	0.4	0.4	1867	2004
c12ten av	93	55		1	11	1.1	0.2	0.1	1868	2005
c12ten av	77	53		1	-3	0.2	0.2	0.5	1849	1986
c12ten av	73	51		1	-29	2.6	0.5	0.1	1845	1982
c12ten av	79	60	*	0	1	0.1	0.0	0.1	1851	1988

Sample (=HalfCh): 003Aobl av 0 122 1881 2002
Reference (=HalfCh): c08ten av 0 93 1910 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003Aobl av	90	63	**	19	9	0.9	3.0	3.2	1878	1999
003Aobl av	93	53		11	21	2.1	2.5	1.6	1881	2002
003Aobl av	91	48		11	3	0.3	2.3	2.6	1879	2000
003Aobl av	93	53		10	30	3.0	2.4	1.5	1884	2005
003Aobl av	80	58		7	38	3.6	1.5	1.0	1868	1989

003Aobl av	86	54		7	22	2.0	1.9	1.0	1874	1995
003Aobl av	71	54		6	38	3.5	1.5	1.0	1859	1980
003Aobl av	73	51		6	31	2.8	1.3	1.1	1861	1982
003Aobl av	79	55		5	28	2.6	0.8	1.3	1867	1988
003Aobl av	72	51		5	40	3.6	1.3	0.9	1860	1981
003Aobl av	74	58		4	32	2.9	0.7	0.7	1862	1983
003Aobl av	87	55		4	11	1.0	1.0	0.5	1875	1996
003Aobl av	83	56		2	21	2.0	0.6	0.3	1871	1992
003Aobl av	75	52		2	17	1.5	0.3	0.7	1863	1984
003Aobl av	82	51		2	29	2.7	0.5	0.2	1870	1991
003Aobl av	93	51		2	28	2.8	0.3	0.4	1883	2004
003Aobl av	77	51		2	10	0.8	0.5	0.3	1865	1986
003Aobl av	84	51		2	20	1.8	0.5	0.2	1872	1993
003Aobl av	93	59	*	0	13	1.2	0.1	0.0	1885	2006

Sample (=HalfCh): 003obl av 0 131 1872 2002
Reference (=HalfCh): c08ten av 0 93 1910 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
003obl av	88	56		15	29	2.8	2.3	3.2	1867	1997
003obl av	93	56		10	40	4.1	2.2	1.4	1873	2003
003obl av	73	63	*	8	14	1.2	1.1	1.7	1852	1982
003obl av	93	52		8	14	1.3	2.3	0.8	1875	2005
003obl av	87	51		8	16	1.5	1.2	2.2	1866	1996
003obl av	83	55		7	42	4.2	1.4	1.4	1862	1992
003obl av	90	56		4	23	2.3	0.3	1.0	1869	1999
003obl av	81	53		4	19	1.8	1.4	0.2	1860	1990
003obl av	82	51		4	27	2.5	0.6	1.1	1861	1991
003obl av	86	51		4	21	1.9	1.3	0.2	1865	1995
003obl av	71	59		3	30	2.6	0.4	0.8	1850	1980
003obl av	84	55		3	38	3.7	0.9	0.3	1863	1993
003obl av	77	55		1	10	0.8	0.0	0.4	1856	1986

Sample (=HalfCh): 004ten av 0 77 1926 2002
Reference (=HalfCh): c08ten av 0 93 1910 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
004ten av	77	45		15	-40	3.8	3.6	3.1	1916	1992
004ten av	77	55		14	-9	0.7	2.6	2.4	1917	1993
004ten av	73	46		11	-21	1.8	2.8	1.9	1930	2006
004ten av	77	51		9	15	1.3	1.4	2.1	1912	1988
004ten av	77	61	*	8	-4	0.3	0.9	1.6	1921	1997
004ten av	77	57		7	-12	1.1	1.1	1.3	1914	1990
004ten av	75	51		6	-27	2.4	1.2	1.2	1908	1984
004ten av	77	56		5	4	0.4	1.3	0.4	1911	1987
004ten av	74	51		5	-16	1.3	1.1	1.0	1907	1983
004ten av	77	51		5	32	2.9	0.9	0.9	1926	2002
004ten av	77	63	**	4	-6	0.5	0.6	0.6	1919	1995
004ten av	77	57		4	30	2.7	0.7	0.6	1925	2001
004ten av	73	57		2	-13	1.1	0.8	0.1	1906	1982
004ten av	71	60	*	1	-14	1.1	0.3	0.1	1904	1980
004ten av	75	59		1	8	0.7	0.2	0.1	1928	2004
004ten av	77	58		1	8	0.7	0.1	0.4	1923	1999
004ten av	77	53		1	3	0.2	0.0	0.5	1913	1989

```
Sample    (=HalfCh): 006pul av                           0      134  1869  2002
Reference (=HalfCh): c08ten av                           0       93  1910  2002

  Sample    OVL Glk GSL    CDI  %CC     TV  TVBP  TVH   DateL  DateR
006pul av    93  65 **      25   37    3.8   3.6   4.0   1873   2006
006pul av    82  68 ***     18   28    2.6   3.1   2.4   1858   1991
006pul av    77  43         10  -31    2.8   2.7   2.3   1853   1986
006pul av    93  37         10    6    0.6   2.5   2.7   1872   2005
006pul av    93  57          9   -2    0.2   2.5   0.8   1869   2002
006pul av    75  56          9  -12    1.0   2.4   0.9   1851   1984
006pul av    85  54          7   28    2.7   1.1   1.6   1861   1994
006pul av    80  50          7   -7    0.6   2.1   1.1   1856   1989
006pul av    76  53          6  -14    1.2   1.5   0.9   1852   1985
006pul av    72  60 *        5  -13    1.1   1.0   0.7   1848   1981
006pul av    84  57          5   27    2.5   1.2   0.8   1860   1993
006pul av    78  57          4  -17    1.5   0.6   0.8   1854   1987
006pul av    91  56          3  -17    1.6   0.8   0.2   1867   2000
006pul av    73  51          3  -19    1.7   1.2   0.4   1849   1982
006pul av    86  54          2   15    1.4   0.4   0.4   1862   1995
006pul av    87  53          0   11    1.0   0.2   0.0   1863   1996
-----------------------------------------------------------------

Sample    (=HalfCh): 007ten av                           0       94  1910  2003
Reference (=HalfCh): c08ten av                           0       93  1910  2002

  Sample    OVL Glk GSL    CDI  %CC     TV  TVBP  TVH   DateL  DateR
007ten av    93  93 ***     96   96   32.3  14.4   6.2   1909   2002
007ten av    92  44         16   31    3.1   4.5   3.0   1911   2004
007ten av    91  47         12   34    3.4   3.9   1.2   1907   2000
007ten av    78  64 **      10   12    1.0   1.7   1.6   1894   1987
007ten av    71  58          8    6    0.5   2.5   0.8   1887   1980
007ten av    87  57          7   14    1.3   1.8   0.8   1903   1996
007ten av    81  55          7   19    1.7   1.4   1.2   1897   1990
007ten av    86  55          6    8    0.7   1.3   0.9   1902   1995
007ten av    83  54          4    6    0.5   0.7   0.9   1899   1992
007ten av    90  52          4   22    2.2   0.9   0.8   1906   1999
007ten av    92  39          4   58    6.8   1.1   1.1   1908   2001
007ten av    74  57          3   -1    0.1   0.4   0.7   1890   1983
007ten av    75  52          3   -1    0.1   0.7   0.7   1891   1984
007ten av    80  54          2   11    1.0   0.8   0.0   1896   1989
007ten av    76  51          2    3    0.2   0.6   0.5   1892   1985
007ten av    88  51          2   15    1.4   0.5   0.1   1904   1997
007ten av    72  50          2   -4    0.3   0.6   0.1   1888   1981
007ten av    93  42          2   56    6.5   0.5   0.5   1910   2003
-----------------------------------------------------------------

Sample    (=HalfCh): 008ten av                           0       99  1904  2002
Reference (=HalfCh): c08ten av                           0       93  1910  2002

  Sample    OVL Glk GSL    CDI  %CC     TV  TVBP  TVH   DateL  DateR
008ten av    90  57         13   -8    0.7   2.3   2.4   1901   1999
008ten av    71  58         10  -26    2.2   1.8   1.9   1882   1980
008ten av    93  59 *        8  -10    1.0   1.5   1.1   1907   2005
008ten av    75  62 *        7    1    0.1   1.2   1.5   1886   1984
008ten av    76  54          5    9    0.8   1.1   0.9   1887   1985
008ten av    77  57          4    7    0.6   0.8   0.7   1888   1986
```

008ten av	92	57		4	-22	2.1	0.2	1.1	1903	2001
008ten av	85	53		4	-19	1.8	1.1	0.3	1896	1994
008ten av	88	52		4	-17	1.6	0.3	1.3	1899	1997
008ten av	78	51		4	4	0.3	0.8	0.7	1889	1987
008ten av	73	50		4	-23	2.0	0.1	1.8	1884	1982
008ten av	83	54		3	-22	2.0	0.4	0.8	1894	1992
008ten av	93	53		3	-28	2.8	1.0	0.3	1905	2003
008ten av	81	53		2	-28	2.6	0.7	0.1	1892	1990
008ten av	79	52		2	-10	0.9	0.6	0.1	1890	1988

Sample (=HalfCh): 009ten av 0 74 1929 2002
Reference (=HalfCh): c08ten av 0 93 1910 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
009ten av	71	56		14	22	1.9	3.0	2.3	1932	2005
009ten av	73	39		11	-12	1.0	3.0	2.5	1930	2003
009ten av	74	59		10	16	1.4	1.7	1.5	1910	1983
009ten av	70	57		7	22	1.9	1.1	1.2	1933	2006
009ten av	74	54		6	-20	1.7	1.2	0.8	1925	1998
009ten av	74	52		6	35	3.2	1.0	1.4	1915	1988
009ten av	71	62	*	5	1	0.1	0.8	0.7	1907	1980
009ten av	74	56		5	-10	0.9	0.7	0.9	1922	1995
009ten av	74	54		5	5	0.4	0.9	0.9	1920	1993
009ten av	74	54		4	-10	0.9	0.7	0.7	1926	1999
009ten av	74	57		3	0	0.0	0.9	0.3	1927	2000
009ten av	74	53		3	31	2.7	0.5	0.6	1916	1989
009ten av	74	53		3	30	2.7	0.5	0.6	1917	1990
009ten av	74	51		3	-6	0.5	0.5	0.5	1929	2002
009ten av	73	53		2	9	0.7	0.3	0.3	1909	1982
009ten av	74	52		2	-5	0.4	0.4	0.3	1928	2001
009ten av	74	50		2	-6	0.5	0.2	0.7	1921	1994
009ten av	72	50		2	4	0.3	0.7	0.1	1931	2004
009ten av	74	53		1	29	2.6	0.1	0.4	1913	1986
009ten av	74	52		1	37	3.4	0.4	0.0	1914	1987

Sample (=HalfCh): c04obl av 0 155 1848 2002
Reference (=HalfCh): c08ten av 0 93 1910 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c04obl av	93	55		17	28	2.8	3.3	3.0	1848	2002
c04obl av	88	52		12	24	2.3	2.7	2.0	1843	1997
c04obl av	78	59		10	-2	0.2	1.8	1.9	1833	1987
c04obl av	86	46		10	0	0.0	2.7	1.7	1841	1995
c04obl av	93	57		7	25	2.4	1.4	1.2	1851	2005
c04obl av	92	59	*	6	10	1.0	0.3	1.7	1847	2001
c04obl av	81	54		6	6	0.5	0.9	1.4	1836	1990
c04obl av	80	50		6	-6	0.5	1.5	1.2	1835	1989
c04obl av	74	54		4	-5	0.5	0.9	0.6	1829	1983
c04obl av	84	54		4	4	0.4	0.5	0.9	1839	1993
c04obl av	83	56		3	8	0.7	0.5	0.5	1838	1992
c04obl av	90	51		3	1	0.1	0.9	0.2	1845	1999
c04obl av	89	54		2	16	1.5	0.7	0.2	1844	1998
c04obl av	73	54		2	-7	0.6	0.7	0.2	1828	1982
c04obl av	75	53		2	-10	0.8	0.4	0.4	1830	1984
c04obl av	93	52		2	23	2.2	0.7	0.0	1850	2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c04obl av	77	55		1	-7	0.6	0.0	0.5	1832	1986

Sample (=HalfCh): c06pul av 0 130 1873 2002
Reference (=HalfCh): c08ten av 0 93 1910 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c06pul av	79	56		18	-4	0.4	3.0	3.7	1859	1988
c06pul av	90	55		5	-4	0.4	0.8	0.9	1870	1999
c06pul av	88	59		4	-1	0.1	0.4	1.0	1868	1997
c06pul av	93	53		4	-8	0.8	1.3	0.3	1873	2002
c06pul av	84	51		4	-6	0.6	0.5	1.1	1864	1993
c06pul av	81	54		3	-7	0.6	0.1	1.2	1861	1990
c06pul av	89	53		3	-3	0.3	0.8	0.5	1869	1998
c06pul av	85	52		3	-17	1.6	0.3	1.0	1865	1994
c06pul av	76	52		3	-28	2.5	0.4	0.8	1856	1985
c06pul av	83	56		2	-12	1.1	0.4	0.5	1863	1992
c06pul av	74	53		2	-3	0.3	0.3	0.3	1854	1983
c06pul av	75	51		2	-14	1.2	0.2	0.5	1855	1984
c06pul av	71	53		1	-2	0.2	0.4	0.1	1851	1980
c06pul av	93	52		1	-15	1.4	0.4	0.1	1874	2003
c06pul av	92	52		1	-11	1.0	0.0	0.5	1872	2001

Sample (=HalfCh): c07obl av 0 114 1889 2002
Reference (=HalfCh): c08ten av 0 93 1910 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c07obl av	79	66	**	11	10	0.9	2.0	1.5	1875	1988
c07obl av	86	61	*	9	9	0.8	1.5	1.4	1882	1995
c07obl av	73	53		8	-14	1.2	1.9	1.7	1869	1982
c07obl av	84	59	*	7	3	0.3	0.7	1.9	1880	1993
c07obl av	93	58		7	29	2.9	0.9	1.4	1890	2003
c07obl av	81	55		6	-5	0.4	0.9	1.2	1877	1990
c07obl av	92	49		5	47	5.1	1.0	1.2	1888	2001
c07obl av	82	54		4	-4	0.4	0.5	1.1	1878	1991
c07obl av	76	52		4	1	0.1	1.0	0.6	1872	1985
c07obl av	93	58		3	15	1.4	0.4	0.5	1892	2005
c07obl av	90	55		2	40	4.1	0.1	0.5	1886	1999
c07obl av	71	54		2	-16	1.4	0.3	0.7	1867	1980
c07obl av	88	54		2	21	1.9	0.5	0.4	1884	1997
c07obl av	93	52		2	34	3.5	0.1	0.7	1889	2002
c07obl av	77	51		0	6	0.5	0.1	0.0	1873	1986

Sample (=HalfCh): c08ten av 0 93 1910 2002
Reference (=HalfCh): c08ten av 0 93 1910 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
c08ten av	93	100	***	1000	100	100.0	100.0	100.0	1910	2002
c08ten av	78	65	**	13	14	1.2	2.2	2.0	1895	1987
c08ten av	92	38		11	55	6.2	1.8	3.9	1909	2001
c08ten av	92	38		11	55	6.2	1.8	3.9	1911	2003
c08ten av	91	46		10	35	3.5	4.0	0.6	1908	2000
c08ten av	91	46		10	35	3.5	4.0	0.6	1912	2004
c08ten av	87	57		9	14	1.3	2.0	1.1	1904	1996
c08ten av	71	57		8	5	0.4	2.4	0.6	1888	1980

c08ten av	81	54	8	20	1.8	1.7	1.4	1898	1990
c08ten av	75	53	5	1	0.1	1.2	1.0	1892	1984
c08ten av	90	52	5	22	2.1	1.1	0.9	1907	1999
c08ten av	90	52	5	22	2.1	1.1	0.9	1913	2005
c08ten av	80	53	4	11	1.0	1.2	0.3	1897	1989
c08ten av	76	52	4	3	0.2	0.9	0.7	1893	1985
c08ten av	86	52	4	7	0.7	1.0	0.5	1903	1995
c08ten av	74	56	2	-1	0.1	0.2	0.6	1891	1983
c08ten av	88	52	1	15	1.4	0.5	0.0	1905	1997
c08ten av	72	51	1	1	0.0	0.2	0.5	1889	1981
c08ten av	83	51	0	3	0.3	0.0	0.0	1900	1992

*** End of cross-date job. ***

Appendix 2

Cross dating results for the averaged series from the old trees.

```
*****************************************************************
*** TSAP CROSS-DATING   ***  All results of sample and references:
-> MinLeftOverlap=50 / MinRightOverlap=50
-> Chrono signature conditions: Density>4 / Internal Glk>50
-> Results listed for each reference-sample pair.
-> List all results
-> Match acceptance: logical OR - connection of threshold values,
   one of the following threshold values has to be exceeded.
   Threshold conditions:
   Glk%>50  SGlk%>50  SSGlk%>50  TV>5.0  CrC>0.5  CDI>10
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```
Sample    (=HalfCh): SW59C1 av                    0      212  1794  2005
Reference (=HalfCh): SW59C1 av                    0      212  1794  2005
```

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C1 av	212	100	***	1000	100	100.0	100.0	100.0	1794	2005
SW59C1 av	211	29		18	12	1.8	4.3	8.2	1793	2004
SW59C1 av	211	29		18	12	1.8	4.3	8.2	1795	2006
SW59C1 av	210	55		14	13	2.0	4.8	0.3	1792	2003
SW59C1 av	207	55		8	10	1.4	1.9	1.0	1789	2000
SW59C1 av	191	54		7	6	0.8	1.5	1.0	1773	1984
SW59C1 av	200	51		6	5	0.7	1.0	1.2	1782	1993
SW59C1 av	204	56	*	3	-6	0.9	0.0	0.9	1786	1997
SW59C1 av	196	54		3	16	2.2	0.4	0.6	1778	1989
SW59C1 av	195	51		3	13	1.8	0.6	0.4	1777	1988
SW59C1 av	193	53		2	4	0.6	0.7	0.2	1775	1986
SW59C1 av	198	53		2	9	1.3	0.2	0.7	1780	1991
SW59C1 av	209	50		2	5	0.8	0.7	0.2	1791	2002
SW59C1 av	188	52		1	-4	0.6	0.1	0.2	1770	1981
SW59C1 av	202	51		1	-4	0.5	0.0	0.4	1784	1995
SW59C1 av	201	51		1	-4	0.6	0.0	0.6	1783	1994

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```
Sample    (=HalfCh): SW59C10 av                   0      151  1854  2004
Reference (=HalfCh): SW59C1 av                    0      212  1794  2005
```

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C10 av	151	66	***	17	23	2.9	1.8	3.2	1833	1983
SW59C10 av	151	55		6	14	1.7	0.5	1.5	1831	1981
SW59C10 av	151	53		6	0	0.0	1.4	0.9	1850	2000
SW59C10 av	151	52		5	13	1.7	0.6	1.3	1835	1985
SW59C10 av	150	59	*	4	0	0.0	0.5	1.0	1856	2006
SW59C10 av	151	55		4	-1	0.2	0.6	1.0	1854	2004
SW59C10 av	151	53		4	9	1.1	0.7	0.8	1845	1995
SW59C10 av	151	53		4	-9	1.1	0.8	0.8	1853	2003
SW59C10 av	151	52		4	3	0.4	1.0	0.4	1847	1997
SW59C10 av	151	54		2	11	1.3	0.4	0.2	1838	1988
SW59C10 av	151	54		2	-4	0.5	0.4	0.2	1848	1998
SW59C10 av	151	52		2	3	0.4	0.2	0.4	1843	1993
SW59C10 av	151	50		2	4	0.4	0.4	0.5	1840	1990
SW59C10 av	151	52		1	-2	0.2	0.1	0.4	1830	1980

Sample	(=HalfCh): SW59C11 av	0	177	1828	2004
Reference	(=HalfCh): SW59C1 av	0	212	1794	2005

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C11 av	177	63	***	25	22	3.0	3.7	4.2	1804	1980
SW59C11 av	177	61	**	7	4	0.6	2.0	0.5	1809	1985
SW59C11 av	177	54		7	2	0.3	1.0	1.5	1812	1988
SW59C11 av	177	51		5	10	1.3	0.9	1.0	1828	2004
SW59C11 av	177	54		4	-4	0.5	1.0	0.6	1826	2002
SW59C11 av	177	53		4	-5	0.6	1.0	0.4	1806	1982
SW59C11 av	177	53		4	5	0.7	0.7	0.7	1823	1999
SW59C11 av	176	59	*	3	11	1.4	0.5	0.4	1830	2006
SW59C11 av	177	54		3	4	0.6	0.5	0.5	1816	1992
SW59C11 av	177	53		2	-1	0.2	0.7	0.0	1824	2000
SW59C11 av	177	53		1	5	0.6	0.1	0.1	1818	1994
SW59C11 av	177	52		1	2	0.2	0.0	0.3	1821	1997
SW59C11 av	177	52		1	5	0.7	0.1	0.4	1814	1990
SW59C11 av	177	52		1	2	0.2	0.0	0.3	1820	1996

Sample	(=HalfCh): SW59C2 av	0	230	1775	2004
Reference	(=HalfCh): SW59C1 av	0	212	1794	2005

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C2 av	212	45		14	-9	1.3	3.8	2.6	1777	2006
SW59C2 av	192	58	*	13	12	1.7	2.2	2.6	1756	1985
SW59C2 av	200	48		12	3	0.4	2.5	2.5	1764	1993
SW59C2 av	211	54		11	8	1.2	2.3	1.9	1775	2004
SW59C2 av	199	52		10	23	3.3	1.5	2.5	1763	1992
SW59C2 av	210	46		10	-8	1.2	2.0	2.4	1774	2003
SW59C2 av	196	45		10	-5	0.7	2.3	2.3	1760	1989
SW59C2 av	197	56	*	7	15	2.1	0.8	1.7	1761	1990
SW59C2 av	205	50		7	-3	0.4	1.8	1.0	1769	1998
SW59C2 av	212	53		6	3	0.5	1.5	0.9	1776	2005
SW59C2 av	203	53		6	16	2.3	1.3	1.0	1767	1996
SW59C2 av	194	52		6	6	0.9	0.9	1.4	1758	1987
SW59C2 av	207	51		5	6	0.8	1.0	1.0	1771	2000
SW59C2 av	195	57	*	4	7	1.0	0.8	0.5	1759	1988
SW59C2 av	209	51		4	3	0.5	0.2	1.4	1773	2002
SW59C2 av	190	53		3	2	0.2	0.6	0.5	1754	1983
SW59C2 av	202	51		2	17	2.5	0.8	0.2	1766	1995
SW59C2 av	188	55		1	4	0.6	0.2	0.3	1752	1981

Sample	(=HalfCh): SW59C5 av	0	206	1802	2007
Reference	(=HalfCh): SW59C1 av	0	212	1794	2005

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C5 av	191	61	**	12	0	0.0	2.3	1.6	1779	1984
SW59C5 av	206	49		11	-17	2.4	2.8	1.7	1797	2002
SW59C5 av	205	49		10	-15	2.1	2.1	2.0	1793	1998
SW59C5 av	195	54		7	9	1.2	1.3	1.3	1783	1988
SW59C5 av	201	52		7	7	1.0	1.3	1.4	1789	1994
SW59C5 av	206	51		7	0	0.1	1.9	1.0	1799	2004

SW59C5 av	200	53		6	-5	0.7	1.3	0.9	1788	1993
SW59C5 av	206	53		6	0	0.1	1.4	0.9	1798	2003
SW59C5 av	188	51		6	-5	0.7	1.6	0.9	1776	1981
SW59C5 av	189	54		5	-13	1.8	1.4	0.7	1777	1982
SW59C5 av	193	54		4	-9	1.3	1.3	0.1	1781	1986
SW59C5 av	206	52		4	-6	0.9	0.9	0.8	1794	1999
SW59C5 av	203	54		3	-5	0.6	0.2	0.9	1791	1996
SW59C5 av	206	51		3	-15	2.2	0.9	0.1	1796	2001
SW59C5 av	194	50		3	-7	1.0	0.4	0.7	1782	1987
SW59C5 av	206	55		2	-6	0.9	0.6	0.2	1800	2005
SW59C5 av	198	50		2	-6	0.9	0.0	0.6	1786	1991
SW59C5 av	197	55		1	1	0.2	0.3	0.3	1785	1990
SW59C5 av	187	51		1	-11	1.5	0.2	0.0	1775	1980

Sample	(=HalfCh): SW59C6 av	0	198	1806	2003
Reference	(=HalfCh): SW59C1 av	0	212	1794	2005

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C6 av	198	57	*	15	18	2.6	2.8	2.4	1804	2001
SW59C6 av	198	54		14	15	2.2	2.4	2.8	1798	1995
SW59C6 av	192	56		9	9	1.2	1.6	1.8	1788	1985
SW59C6 av	189	54		7	9	1.2	1.8	0.9	1785	1982
SW59C6 av	198	58	**	6	4	0.5	1.0	1.0	1794	1991
SW59C6 av	198	52		5	5	0.7	1.3	0.5	1806	2003
SW59C6 av	198	52		3	3	0.5	0.6	0.4	1808	2005
SW59C6 av	188	51		3	-2	0.3	0.8	0.2	1784	1981
SW59C6 av	198	55		2	3	0.4	0.0	0.6	1800	1997
SW59C6 av	194	54		2	0	0.0	0.3	0.4	1790	1987
SW59C6 av	197	51		2	11	1.5	0.9	0.0	1809	2006
SW59C6 av	196	54		1	3	0.4	0.0	0.4	1792	1989
SW59C6 av	198	51		1	12	1.6	0.3	0.1	1805	2002
SW59C6 av	191	51		1	7	0.9	0.1	0.3	1787	1984

Sample	(=HalfCh): SW59C7 av	0	153	1850	2002
Reference	(=HalfCh): SW59C1 av	0	212	1794	2005

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C7 av	153	57	*	14	18	2.2	2.6	2.3	1852	2004
SW59C7 av	153	44		11	-1	0.1	2.4	2.4	1853	2005
SW59C7 av	153	55		7	10	1.2	1.3	1.1	1846	1998
SW59C7 av	153	55		7	5	0.6	1.0	1.6	1831	1983
SW59C7 av	153	53		7	-4	0.5	1.1	1.5	1835	1987
SW59C7 av	153	51		7	8	1.0	1.5	1.4	1842	1994
SW59C7 av	153	55		5	10	1.2	1.3	0.5	1847	1999
SW59C7 av	153	54		5	10	1.3	1.2	0.8	1841	1993
SW59C7 av	153	50		4	5	0.6	1.1	0.7	1838	1990
SW59C7 av	153	50		4	0	0.0	0.9	0.7	1839	1991
SW59C7 av	153	53		3	-6	0.7	0.8	0.1	1844	1996
SW59C7 av	153	52		3	-9	1.1	0.4	0.7	1836	1988
SW59C7 av	153	50		3	1	0.1	0.8	0.4	1851	2003
SW59C7 av	153	56		2	-2	0.3	0.7	0.0	1849	2001
SW59C7 av	153	52		2	-5	0.6	0.3	0.6	1833	1985
SW59C7 av	153	50		2	-3	0.4	0.6	0.2	1829	1981
SW59C7 av	152	52		1	11	1.4	0.0	0.5	1854	2006

Sample	(=HalfCh):	SW59C9 av	0	163	1841	2003
Reference	(=HalfCh):	SW59C1 av	0	212	1794	2005

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C9 av	163	60	**	11	13	1.7	1.8	1.9	1822	1984
SW59C9 av	163	53		11	20	2.5	2.1	1.9	1839	2001
SW59C9 av	163	55		8	20	2.5	1.7	1.0	1825	1987
SW59C9 av	163	53		8	12	1.5	1.0	1.9	1843	2005
SW59C9 av	163	56		7	1	0.2	1.4	1.1	1830	1992
SW59C9 av	163	54		6	13	1.7	1.5	0.7	1835	1997
SW59C9 av	163	55		4	9	1.2	0.6	1.0	1820	1982
SW59C9 av	163	53		4	9	1.2	0.2	1.3	1841	2003
SW59C9 av	163	52		4	-4	0.5	1.1	0.4	1828	1990
SW59C9 av	162	55		2	7	0.9	0.5	0.3	1844	2006
SW59C9 av	163	55		1	6	0.8	0.2	0.3	1836	1998
SW59C9 av	163	52		1	1	0.2	0.3	0.2	1833	1995
SW59C9 av	163	51		1	4	0.5	0.2	0.2	1827	1989
SW59C9 av	163	50		0	-2	0.2	0.0	0.2	1832	1994

Sample	(=HalfCh):	SW59C1 av	0	212	1794	2005
Reference	(=HalfCh):	SW59C10 av	0	151	1854	2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C1 av	135	52		12	21	2.5	2.6	2.3	1777	1988
SW59C1 av	147	54		9	6	0.7	1.9	1.6	1789	2000
SW59C1 av	133	53		7	-4	0.5	1.9	0.9	1775	1986
SW59C1 av	150	59	*	4	0	0.0	0.5	1.0	1792	2003
SW59C1 av	151	55		4	-1	0.2	0.6	1.0	1794	2005
SW59C1 av	151	53		4	-9	1.1	0.8	0.8	1795	2006
SW59C1 av	138	59	*	3	2	0.2	0.6	0.6	1780	1991
SW59C1 av	142	56		3	12	1.5	0.9	0.1	1784	1995
SW59C1 av	130	56		2	12	1.4	0.6	0.1	1772	1983
SW59C1 av	145	53		2	0	0.0	0.6	0.2	1787	1998
SW59C1 av	132	53		2	5	0.6	0.5	0.5	1774	1985
SW59C1 av	127	52		2	8	0.9	0.1	0.7	1769	1980
SW59C1 av	129	52		2	6	0.7	0.4	0.2	1771	1982
SW59C1 av	136	51		2	7	0.8	0.3	0.6	1778	1989
SW59C1 av	144	52		1	1	0.2	0.3	0.1	1786	1997
SW59C1 av	148	52		1	-2	0.2	0.1	0.1	1790	2001
SW59C1 av	143	51		1	4	0.5	0.2	0.1	1785	1996

Sample	(=HalfCh):	SW59C10 av	0	151	1854	2004
Reference	(=HalfCh):	SW59C10 av	0	151	1854	2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C10 av	151	100	***	1000	100	100.0	100.0	100.0	1854	2004
SW59C10 av	149	44		17	6	0.8	6.6	1.3	1852	2002
SW59C10 av	149	44		17	6	0.8	6.6	1.3	1856	2006
SW59C10 av	150	39		17	17	2.1	2.9	5.9	1855	2005
SW59C10 av	150	39		17	17	2.1	2.9	5.9	1853	2003
SW59C10 av	147	54		14	28	3.6	3.5	1.6	1850	2000
SW59C10 av	142	59	*	10	20	2.4	1.7	2.0	1845	1995

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C10 av	128	60	*	8	3	0.4	1.8	0.9	1831	1981
SW59C10 av	138	55		8	11	1.3	1.3	1.8	1841	1991
SW59C10 av	144	50		7	-1	0.1	1.7	1.0	1847	1997
SW59C10 av	145	52		6	1	0.1	1.8	0.4	1848	1998
SW59C10 av	136	51		4	0	0.0	0.2	1.5	1839	1989
SW59C10 av	134	52		3	-1	0.1	0.2	0.8	1837	1987
SW59C10 av	127	52		3	-4	0.4	0.1	1.1	1830	1980
SW59C10 av	131	56		1	-1	0.1	0.3	0.2	1834	1984
SW59C10 av	133	53		1	-2	0.2	0.4	0.2	1836	1986

Sample	(=HalfCh): SW59C11 av	0	177	1828	2004
Reference	(=HalfCh): SW59C10 av	0	151	1854	2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C11 av	134	59	*	8	15	1.8	0.8	1.9	1811	1987
SW59C11 av	127	56		7	13	1.5	1.2	1.5	1804	1980
SW59C11 av	136	52		7	18	2.1	1.1	1.6	1813	1989
SW59C11 av	138	51		6	12	1.4	1.2	1.0	1815	1991
SW59C11 av	145	57	*	5	11	1.3	1.1	0.7	1822	1998
SW59C11 av	148	55		5	11	1.4	1.0	0.8	1825	2001
SW59C11 av	140	54		5	15	1.7	1.4	0.7	1817	1993
SW59C11 av	144	52		5	12	1.5	1.3	0.5	1821	1997
SW59C11 av	139	56		4	20	2.4	0.9	0.7	1816	1992
SW59C11 av	132	51		4	11	1.3	0.4	1.1	1809	1985
SW59C11 av	130	50		4	5	0.6	0.7	1.1	1807	1983
SW59C11 av	131	51		2	5	0.5	0.4	0.5	1808	1984
SW59C11 av	150	50		1	6	0.8	0.0	0.2	1827	2003
SW59C11 av	143	50		0	3	0.4	0.0	0.0	1820	1996

Sample	(=HalfCh): SW59C2 av	0	230	1775	2004
Reference	(=HalfCh): SW59C10 av	0	151	1854	2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C2 av	151	62	**	13	25	3.2	1.7	2.5	1775	2004
SW59C2 av	151	46		13	4	0.5	2.7	3.0	1776	2005
SW59C2 av	147	57		12	19	2.3	1.9	2.2	1771	2000
SW59C2 av	130	54		12	10	1.2	1.5	3.1	1754	1983
SW59C2 av	148	44		12	-3	0.4	2.7	3.0	1772	2001
SW59C2 av	131	38		12	-19	2.1	2.6	4.3	1755	1984
SW59C2 av	132	58	*	11	9	1.1	1.1	2.8	1756	1985
SW59C2 av	134	53		9	18	2.1	1.3	2.4	1758	1987
SW59C2 av	141	54		8	15	1.8	1.2	1.9	1765	1994
SW59C2 av	138	54		6	5	0.5	1.1	1.0	1762	1991
SW59C2 av	151	52		6	23	2.9	0.8	1.5	1777	2006
SW59C2 av	150	51		5	14	1.8	1.6	0.5	1774	2003
SW59C2 av	135	52		4	-1	0.1	0.2	1.5	1759	1988
SW59C2 av	144	53		2	7	0.8	0.3	0.5	1768	1997
SW59C2 av	143	52		2	10	1.2	0.4	0.4	1767	1996
SW59C2 av	136	51		2	-6	0.7	0.9	0.1	1760	1989
SW59C2 av	140	50		2	10	1.2	0.2	0.6	1764	1993
SW59C2 av	127	53		0	-5	0.5	0.1	0.1	1751	1980

Sample	(=HalfCh): SW59C5 av	0	206	1802	2007
Reference	(=HalfCh): SW59C10 av	0	151	1854	2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C5 av	131	60	*	14	15	1.7	2.9	2.2	1779	1984
SW59C5 av	148	47		14	-23	2.9	3.4	2.8	1796	2001
SW59C5 av	151	45		12	-16	2.0	2.4	2.9	1801	2006
SW59C5 av	129	57	*	7	-6	0.7	2.1	0.6	1777	1982
SW59C5 av	141	51		7	8	1.0	1.8	1.0	1789	1994
SW59C5 av	127	54		6	0	0.0	1.6	0.9	1775	1980
SW59C5 av	144	54		6	0	0.0	0.5	1.9	1792	1997
SW59C5 av	133	57		5	-10	1.1	1.7	0.1	1781	1986
SW59C5 av	135	57		5	-4	0.5	1.1	0.7	1783	1988
SW59C5 av	151	57	*	4	-4	0.5	0.3	1.0	1800	2005
SW59C5 av	150	52		4	0	0.0	1.2	0.4	1798	2003
SW59C5 av	147	53		3	-13	1.6	0.4	0.7	1795	2000
SW59C5 av	140	55		2	-4	0.4	0.5	0.3	1788	1993
SW59C5 av	137	53		2	-12	1.4	0.3	0.4	1785	1990
SW59C5 av	143	52		2	-6	0.7	0.4	0.3	1791	1996
SW59C5 av	138	52		1	-15	1.8	0.1	0.2	1786	1991

Sample (=HalfCh): SW59C6 av 0 198 1806 2003
Reference (=HalfCh): SW59C10 av 0 151 1854 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C6 av	148	46		13	-13	1.6	2.4	3.1	1804	2001
SW59C6 av	139	58	*	12	11	1.3	2.4	1.8	1795	1992
SW59C6 av	147	54		11	13	1.6	1.8	2.3	1803	2000
SW59C6 av	143	52		11	14	1.7	2.4	1.9	1799	1996
SW59C6 av	151	58	*	10	6	0.7	2.0	1.4	1808	2005
SW59C6 av	149	52		8	5	0.6	1.1	1.9	1805	2002
SW59C6 av	132	54		7	4	0.5	1.0	1.8	1788	1985
SW59C6 av	136	54		5	1	0.1	1.1	0.9	1792	1989
SW59C6 av	146	56		4	0	0.0	1.1	0.2	1802	1999
SW59C6 av	134	58	*	3	2	0.2	0.1	1.1	1790	1987
SW59C6 av	128	56		3	9	1.0	0.5	0.6	1784	1981
SW59C6 av	130	55		2	6	0.7	0.5	0.3	1786	1983
SW59C6 av	142	53		2	2	0.2	0.9	0.0	1798	1995
SW59C6 av	150	51		2	-5	0.7	0.3	0.5	1806	2003
SW59C6 av	151	50		2	-1	0.1	0.4	0.5	1809	2006
SW59C6 av	140	54		1	2	0.2	0.1	0.2	1796	1993
SW59C6 av	129	52		1	9	1.0	0.2	0.0	1785	1982

Sample (=HalfCh): SW59C7 av 0 153 1850 2002
Reference (=HalfCh): SW59C10 av 0 151 1854 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C7 av	146	57		16	9	1.1	2.8	2.9	1847	1999
SW59C7 av	141	63	**	11	11	1.3	2.0	1.7	1842	1994
SW59C7 av	132	60	**	10	15	1.7	2.0	1.7	1833	1985
SW59C7 av	148	51		8	-6	0.7	1.8	1.2	1849	2001
SW59C7 av	128	51		8	-1	0.1	2.0	1.2	1829	1981
SW59C7 av	151	50		8	9	1.1	1.7	1.6	1853	2005
SW59C7 av	149	52		7	6	0.7	1.6	1.3	1850	2002
SW59C7 av	147	50		5	-4	0.5	1.0	1.0	1848	2000
SW59C7 av	136	54		4	9	1.0	1.1	0.6	1837	1989
SW59C7 av	139	54		3	1	0.1	0.6	0.4	1840	1992

SW59C7 av	135	52		3	5	0.6	0.8	0.6	1836	1988
SW59C7 av	150	52		3	4	0.5	0.7	0.5	1851	2003
SW59C7 av	131	51		3	2	0.3	0.6	0.5	1832	1984
SW59C7 av	143	51		2	-14	1.6	0.8	0.1	1844	1996
SW59C7 av	140	50		2	5	0.6	0.6	0.1	1841	1993
SW59C7 av	151	50		2	-11	1.3	0.4	0.6	1854	2006
SW59C7 av	127	50		1	-14	1.6	0.3	0.3	1828	1980
SW59C7 av	137	50		1	1	0.1	0.2	0.2	1838	1990

Sample (=HalfCh): SW59C9 av 0 163 1841 2003
Reference (=HalfCh): SW59C10 av 0 151 1854 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C9 av	151	53		12	20	2.5	1.8	2.7	1843	2005
SW59C9 av	144	55		11	21	2.5	1.6	2.5	1835	1997
SW59C9 av	148	56		5	11	1.4	0.8	1.0	1839	2001
SW59C9 av	131	56		5	-9	1.0	0.7	1.2	1822	1984
SW59C9 av	143	50		5	4	0.4	0.5	1.5	1834	1996
SW59C9 av	142	52		4	10	1.2	0.2	1.4	1833	1995
SW59C9 av	146	53		3	8	0.9	0.6	0.4	1837	1999
SW59C9 av	150	53		3	8	1.0	0.1	1.2	1841	2003
SW59C9 av	128	51		3	-10	1.1	0.7	0.5	1819	1981
SW59C9 av	147	51		3	8	1.0	1.1	0.3	1838	2000
SW59C9 av	135	58	*	2	7	0.8	0.6	0.1	1826	1988
SW59C9 av	127	57		1	-10	1.2	0.1	0.4	1818	1980
SW59C9 av	139	53		1	0	0.0	0.3	0.1	1830	1992
SW59C9 av	132	51		1	-10	1.2	0.0	0.2	1823	1985
SW59C9 av	133	50		0	-5	0.6	0.2	0.0	1824	1986

Sample (=HalfCh): SW59C1 av 0 212 1794 2005
Reference (=HalfCh): SW59C11 av 0 177 1828 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C1 av	159	59	*	12	21	2.7	1.8	2.3	1775	1986
SW59C1 av	157	59	*	11	15	1.9	1.5	2.6	1773	1984
SW59C1 av	167	53		6	-4	0.6	0.7	1.6	1783	1994
SW59C1 av	169	52		5	0	0.1	0.7	1.2	1785	1996
SW59C1 av	172	52		5	13	1.7	1.4	0.8	1788	1999
SW59C1 av	177	51		5	10	1.3	0.9	1.0	1794	2005
SW59C1 av	161	52		4	2	0.2	1.2	0.2	1777	1988
SW59C1 av	165	52		4	-2	0.2	0.5	1.1	1781	1992
SW59C1 av	176	59	*	3	11	1.4	0.5	0.4	1792	2003
SW59C1 av	155	57	*	3	-1	0.2	0.3	0.7	1771	1982
SW59C1 av	164	51		3	-3	0.4	0.3	0.8	1780	1991
SW59C1 av	162	52		2	0	0.1	0.2	0.5	1778	1989
SW59C1 av	163	52		2	-1	0.1	0.0	0.8	1779	1990
SW59C1 av	175	51		2	6	0.8	0.6	0.1	1791	2002
SW59C1 av	171	53		1	6	0.8	0.3	0.2	1787	1998
SW59C1 av	154	50		0	-9	1.1	0.0	0.1	1770	1981

Sample (=HalfCh): SW59C10 av 0 151 1854 2004
Reference (=HalfCh): SW59C11 av 0 177 1828 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C10 av	151	63	***	18	22	2.7	3.3	2.6	1845	1995
SW59C10 av	151	49		12	-5	0.6	3.2	1.8	1843	1993
SW59C10 av	151	50		10	20	2.5	2.4	1.8	1841	1991
SW59C10 av	151	54		7	8	1.0	1.2	1.3	1834	1984
SW59C10 av	151	55		4	7	0.9	0.6	0.8	1851	2001
SW59C10 av	151	53		4	2	0.3	0.8	0.6	1831	1981
SW59C10 av	151	51		4	0	0.1	1.0	0.6	1839	1989
SW59C10 av	151	53		3	-2	0.3	1.1	0.1	1847	1997
SW59C10 av	151	54		2	1	0.2	0.6	0.2	1848	1998
SW59C10 av	151	56		1	2	0.3	0.1	0.4	1838	1988
SW59C10 av	151	56		1	6	0.7	0.5	0.0	1833	1983
SW59C10 av	150	50		1	6	0.8	0.0	0.2	1855	2005
SW59C10 av	151	52		0	6	0.7	0.0	0.0	1850	2000

Sample (=HalfCh): SW59C11 av 0 177 1828 2004
Reference (=HalfCh): SW59C11 av 0 177 1828 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C11 av	177	100	***	1000	100	100.0	100.0	100.0	1828	2004
SW59C11 av	175	48		17	7	1.0	6.2	0.7	1826	2002
SW59C11 av	175	48		17	7	1.0	6.2	0.7	1830	2006
SW59C11 av	176	38		17	23	3.2	2.7	6.0	1829	2005
SW59C11 av	176	38		17	23	3.2	2.7	6.0	1827	2003
SW59C11 av	173	50		8	13	1.7	1.7	1.5	1824	2000
SW59C11 av	160	56		6	15	2.0	1.4	0.9	1811	1987
SW59C11 av	163	55		5	-5	0.6	0.7	1.0	1814	1990
SW59C11 av	172	51		4	10	1.2	0.8	0.6	1823	1999
SW59C11 av	174	51		4	0	0.0	0.2	1.3	1825	2001
SW59C11 av	155	51		4	-5	0.6	0.9	0.8	1806	1982
SW59C11 av	166	51		3	1	0.1	0.7	0.7	1817	1993
SW59C11 av	165	55		2	-2	0.3	0.3	0.6	1816	1992
SW59C11 av	153	53		1	-2	0.2	0.2	0.1	1804	1980
SW59C11 av	158	50		1	7	0.9	0.4	0.2	1809	1985
SW59C11 av	156	56		0	1	0.1	0.0	0.1	1807	1983
SW59C11 av	167	53		0	-3	0.4	0.0	0.1	1818	1994

Sample (=HalfCh): SW59C2 av 0 230 1775 2004
Reference (=HalfCh): SW59C11 av 0 177 1828 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C2 av	173	58	*	12	16	2.1	2.3	2.1	1771	2000
SW59C2 av	168	57	*	11	14	1.8	1.5	2.3	1766	1995
SW59C2 av	158	50		9	-13	1.7	2.2	1.7	1756	1985
SW59C2 av	156	55		5	5	0.7	1.5	0.5	1754	1983
SW59C2 av	162	53		5	13	1.6	0.9	1.0	1760	1989
SW59C2 av	170	52		5	5	0.7	0.6	1.4	1768	1997
SW59C2 av	177	52		4	9	1.2	0.5	0.9	1777	2006
SW59C2 av	175	50		3	3	0.4	0.9	0.5	1773	2002
SW59C2 av	166	55		2	1	0.2	0.1	0.5	1764	1993
SW59C2 av	154	51		2	0	0.0	0.2	0.5	1752	1981
SW59C2 av	177	51		2	8	1.1	0.1	0.5	1776	2005
SW59C2 av	163	51		2	4	0.5	0.3	0.4	1761	1990
SW59C2 av	161	55		1	9	1.1	0.3	0.0	1759	1988
SW59C2 av	176	53		1	5	0.7	0.2	0.2	1774	2003

Sample	(=HalfCh): SW59C5 av	0	206	1802	2007
Reference	(=HalfCh): SW59C11 av	0	177	1828	2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C5 av	163	59	*	12	4	0.5	2.0	2.3	1785	1990
SW59C5 av	173	55		10	3	0.4	2.1	1.5	1795	2000
SW59C5 av	162	52		7	-11	1.3	1.3	1.5	1784	1989
SW59C5 av	157	51		6	-2	0.2	1.3	1.0	1779	1984
SW59C5 av	175	51		3	-10	1.3	0.6	0.4	1797	2002
SW59C5 av	174	50		2	-6	0.8	0.0	0.7	1796	2001
SW59C5 av	177	55		1	-9	1.2	0.1	0.3	1801	2006
SW59C5 av	176	53		1	-12	1.7	0.1	0.3	1798	2003
SW59C5 av	158	52		1	-8	1.0	0.4	0.1	1780	1985
SW59C5 av	170	52		1	-11	1.4	0.2	0.2	1792	1997
SW59C5 av	165	52		1	-7	0.9	0.4	0.1	1787	1992
SW59C5 av	172	51		1	-5	0.7	0.0	0.2	1794	1999
SW59C5 av	155	50		1	-10	1.2	0.2	0.3	1777	1982
SW59C5 av	167	51		0	-6	0.8	0.1	0.1	1789	1994

Sample	(=HalfCh): SW59C6 av	0	198	1806	2003
Reference	(=HalfCh): SW59C11 av	0	177	1828	2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C6 av	156	55		11	10	1.3	2.6	1.6	1786	1983
SW59C6 av	153	56		8	-6	0.7	1.7	1.6	1783	1980
SW59C6 av	159	61	**	7	-2	0.2	0.6	1.7	1789	1986
SW59C6 av	162	58	*	7	-2	0.2	1.4	1.1	1792	1989
SW59C6 av	166	53		7	-4	0.5	1.6	1.2	1796	1993
SW59C6 av	177	53		7	4	0.5	1.2	1.4	1807	2004
SW59C6 av	165	51		7	-19	2.5	1.6	1.4	1795	1992
SW59C6 av	176	55		6	-8	1.0	0.9	1.2	1806	2003
SW59C6 av	173	52		6	-1	0.2	1.4	0.8	1803	2000
SW59C6 av	174	51		6	0	0.0	1.4	0.9	1804	2001
SW59C6 av	167	51		5	-5	0.6	1.2	0.7	1797	1994
SW59C6 av	171	51		5	-16	2.1	1.2	0.8	1801	1998
SW59C6 av	177	50		5	9	1.2	1.1	1.0	1809	2006
SW59C6 av	169	54		3	-9	1.2	0.7	0.6	1799	1996
SW59C6 av	157	52		2	2	0.3	0.3	0.4	1787	1984

Sample	(=HalfCh): SW59C7 av	0	153	1850	2002
Reference	(=HalfCh): SW59C11 av	0	177	1828	2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C7 av	153	57	*	10	13	1.6	1.7	1.8	1851	2003
SW59C7 av	153	47		10	-9	1.1	2.2	1.9	1846	1998
SW59C7 av	153	57		9	6	0.7	1.4	1.7	1845	1997
SW59C7 av	153	55		8	8	1.0	1.7	1.0	1848	2000
SW59C7 av	153	55		6	0	0.0	0.9	1.3	1840	1992
SW59C7 av	151	59	*	3	1	0.1	0.6	0.5	1854	2006
SW59C7 av	153	57		3	0	0.0	0.3	0.8	1834	1986
SW59C7 av	153	51		3	-7	0.8	0.1	0.9	1839	1991
SW59C7 av	153	51		3	-1	0.1	0.7	0.4	1831	1983
SW59C7 av	153	50		3	-7	0.9	0.3	0.8	1842	1994

SW59C7 av	153	54		2	-1	0.1	0.3	0.5	1833	1985
SW59C7 av	153	51		2	-2	0.2	0.0	0.8	1838	1990
SW59C7 av	153	50		2	-3	0.3	0.4	0.2	1830	1982
SW59C7 av	153	50		2	-1	0.1	0.2	0.6	1836	1988
SW59C7 av	153	50		2	-3	0.3	0.2	0.7	1837	1989
SW59C7 av	153	55		1	0	0.0	0.3	0.2	1828	1980

Sample (=HalfCh): SW59C9 av 0 163 1841 2003
Reference (=HalfCh): SW59C11 av 0 177 1828 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C9 av	163	57	*	16	16	2.1	2.6	2.9	1838	2000
SW59C9 av	160	55		13	8	1.1	2.2	2.6	1825	1987
SW59C9 av	161	55		11	15	1.9	2.3	1.6	1844	2006
SW59C9 av	163	55		7	8	1.1	1.0	1.4	1832	1994
SW59C9 av	154	52		7	11	1.3	0.9	1.9	1819	1981
SW59C9 av	163	55		5	-4	0.4	1.2	0.6	1828	1990
SW59C9 av	163	53		5	-6	0.8	1.5	0.6	1836	1998
SW59C9 av	158	52		4	5	0.6	0.2	1.4	1823	1985
SW59C9 av	163	53		3	9	1.1	0.7	0.5	1841	2003
SW59C9 av	156	52		3	-3	0.4	0.5	0.6	1821	1983
SW59C9 av	163	50		3	-3	0.4	0.8	0.5	1835	1997
SW59C9 av	155	55		2	0	0.0	0.0	0.7	1820	1982
SW59C9 av	163	53		1	0	0.1	0.5	0.0	1830	1992
SW59C9 av	163	52		1	10	1.3	0.1	0.3	1840	2002
SW59C9 av	163	51		1	-6	0.7	0.4	0.1	1829	1991
SW59C9 av	163	50		1	-3	0.3	0.3	0.2	1834	1996

Sample (=HalfCh): SW59C1 av 0 212 1794 2005
Reference (=HalfCh): SW59C2 av 0 230 1775 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C1 av	212	45		14	-9	1.3	3.8	2.6	1792	2003
SW59C1 av	212	52		12	19	2.8	3.0	1.7	1790	2001
SW59C1 av	211	54		11	8	1.2	2.3	1.9	1794	2005
SW59C1 av	210	46		10	-8	1.2	2.0	2.4	1795	2006
SW59C1 av	212	56	*	9	7	1.0	2.0	1.2	1778	1989
SW59C1 av	212	52		8	-5	0.7	1.6	1.6	1776	1987
SW59C1 av	212	53		7	12	1.7	1.1	1.4	1775	1986
SW59C1 av	212	53		6	8	1.2	1.4	0.9	1784	1995
SW59C1 av	212	53		6	3	0.5	1.5	0.9	1793	2004
SW59C1 av	212	52		4	6	0.8	0.5	1.2	1787	1998
SW59C1 av	210	51		4	15	2.1	0.7	1.1	1773	1984
SW59C1 av	207	50		4	2	0.3	1.1	0.4	1770	1981
SW59C1 av	212	51		3	16	2.3	0.6	0.6	1789	2000
SW59C1 av	212	52		2	6	0.9	0.4	0.3	1785	1996
SW59C1 av	208	53		1	8	1.2	0.1	0.5	1771	1982
SW59C1 av	212	51		1	-3	0.4	0.2	0.3	1781	1992
SW59C1 av	212	52		0	-1	0.2	0.0	0.0	1782	1993

Sample (=HalfCh): SW59C10 av 0 151 1854 2004
Reference (=HalfCh): SW59C2 av 0 230 1775 2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR

SW59C10 av	151	62	**	13	25	3.2	1.7	2.5	1854	2004
SW59C10 av	151	46		13	4	0.5	2.7	3.0	1853	2003
SW59C10 av	151	50		11	18	2.3	1.9	2.6	1841	1991
SW59C10 av	151	54		10	15	1.8	2.4	1.5	1838	1988
SW59C10 av	151	53		9	2	0.2	1.8	1.7	1840	1990
SW59C10 av	151	58	*	8	19	2.3	1.4	1.6	1849	1999
SW59C10 av	151	52		7	12	1.5	1.4	1.2	1835	1985
SW59C10 av	151	57	*	6	7	0.8	1.6	0.7	1831	1981
SW59C10 av	151	52		6	23	2.9	0.8	1.5	1852	2002
SW59C10 av	150	51		5	14	1.8	1.6	0.5	1855	2005
SW59C10 av	151	56		3	4	0.5	0.8	0.2	1834	1984
SW59C10 av	151	52		3	11	1.4	1.0	0.1	1846	1996
SW59C10 av	151	51		3	3	0.3	0.8	0.4	1837	1987
SW59C10 av	151	51		3	11	1.4	0.6	0.5	1843	1993
SW59C10 av	151	54		2	12	1.5	0.1	0.5	1847	1997
SW59C10 av	151	52		1	12	1.5	0.1	0.3	1845	1995
SW59C10 av	151	50		1	14	1.8	0.0	0.4	1850	2000

Sample	(=HalfCh): SW59C11 av	0	177	1828	2004
Reference	(=HalfCh): SW59C2 av	0	230	1775	2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C11 av	177	59	**	17	19	2.5	3.5	2.3	1818	1994
SW59C11 av	177	57	*	10	14	1.9	2.0	1.4	1821	1997
SW59C11 av	177	41		10	-2	0.2	2.8	2.1	1819	1995
SW59C11 av	177	53		7	16	2.2	1.6	1.0	1814	1990
SW59C11 av	177	55		6	12	1.6	0.8	1.5	1806	1982
SW59C11 av	177	55		6	14	1.8	1.3	0.8	1811	1987
SW59C11 av	177	55		4	10	1.3	0.5	0.9	1808	1984
SW59C11 av	177	52		4	9	1.2	0.5	0.9	1826	2002
SW59C11 av	177	53		3	8	1.1	0.8	0.3	1817	1993
SW59C11 av	175	50		3	3	0.4	0.9	0.5	1830	2006
SW59C11 av	177	55		2	3	0.4	0.4	0.4	1804	1980
SW59C11 av	177	52		2	6	0.7	0.4	0.2	1815	1991
SW59C11 av	177	51		2	8	1.1	0.1	0.5	1827	2003
SW59C11 av	177	53		1	6	0.8	0.1	0.3	1810	1986
SW59C11 av	176	53		1	5	0.7	0.2	0.2	1829	2005
SW59C11 av	177	51		1	6	0.8	0.3	0.1	1823	1999

Sample	(=HalfCh): SW59C2 av	0	230	1775	2004
Reference	(=HalfCh): SW59C2 av	0	230	1775	2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C2 av	230	100	***	1000	100	100.0	100.0	100.0	1775	2004
SW59C2 av	229	35		22	18	2.8	4.3	8.4	1774	2003
SW59C2 av	229	35		22	18	2.8	4.3	8.4	1776	2005
SW59C2 av	228	47		15	15	2.2	6.2	0.1	1773	2002
SW59C2 av	228	47		15	15	2.2	6.2	0.1	1777	2006
SW59C2 av	223	54		12	19	2.9	2.1	2.2	1768	1997
SW59C2 av	206	50		12	12	1.7	2.5	2.5	1751	1980
SW59C2 av	226	51		7	19	2.9	1.6	1.0	1771	2000
SW59C2 av	219	53		6	7	1.0	0.8	1.4	1764	1993
SW59C2 av	222	50		6	3	0.5	0.8	1.5	1767	1996
SW59C2 av	227	53		5	14	2.2	1.5	0.3	1772	2001
SW59C2 av	215	55		4	5	0.7	0.1	1.2	1760	1989

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SW59C2 av   221  54        4    4   0.6    0.6    0.8    1766     1995
SW59C2 av   217  53        4    7   1.0    0.6    1.2    1762     1991
SW59C2 av   208  54        2    1   0.1    0.0    0.7    1753     1982
SW59C2 av   211  52        2   -1   0.1    0.3    0.4    1756     1985
SW59C2 av   209  51        2    1   0.2    0.7    0.2    1754     1983
SW59C2 av   224  50        2   11   1.6    0.3    0.7    1769     1998
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Sample    (=HalfCh): SW59C5 av                           0       206  1802  2007
Reference (=HalfCh): SW59C2 av                           0       230  1775  2004

  Sample   OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
SW59C5 av   206  48       13  -19   2.8    2.8    2.7    1793     1998
SW59C5 av   204  41       11  -22   3.2    2.7    2.6    1801     2006
SW59C5 av   206  52       10    4   0.5    1.8    2.1    1787     1992
SW59C5 av   206  47       10  -12   1.8    2.3    1.9    1777     1982
SW59C5 av   206  57 *      9   -2   0.2    1.8    1.2    1791     1996
SW59C5 av   206  54        8   -6   0.8    1.1    1.7    1794     1999
SW59C5 av   206  53        6   -8   1.2    1.6    0.7    1799     2004
SW59C5 av   206  53        6    0   0.0    1.0    1.2    1778     1983
SW59C5 av   206  50        6   -6   0.8    1.1    1.3    1776     1981
SW59C5 av   205  57 *      5  -14   2.0    0.6    1.1    1800     2005
SW59C5 av   206  51        4   -2   0.2    1.1    0.5    1784     1989
SW59C5 av   206  50        4   -1   0.1    1.1    0.5    1779     1984
SW59C5 av   206  51        3   -7   1.0    0.5    0.8    1797     2002
SW59C5 av   206  50        3   -4   0.5    0.9    0.5    1789     1994
SW59C5 av   206  53        2   -2   0.3    0.4    0.3    1785     1990
SW59C5 av   206  53        2  -10   1.4    0.1    0.5    1781     1986
SW59C5 av   206  51        1   -9   1.3    0.1    0.4    1796     2001
SW59C5 av   206  50        1    0   0.0    0.2    0.4    1790     1995
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Sample    (=HalfCh): SW59C6 av                           0       198  1806  2003
Reference (=HalfCh): SW59C2 av                           0       230  1775  2004

  Sample   OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
SW59C6 av   198  59 **    12    7   1.0    1.5    2.5    1790     1987
SW59C6 av   198  58 *     12    6   0.8    1.7    2.5    1803     2000
SW59C6 av   198  42       10   -5   0.8    2.2    2.8    1791     1988
SW59C6 av   198  37       10   -9   1.2    2.5    3.2    1802     1999
SW59C6 av   198  51        9   -1   0.1    1.6    2.1    1786     1983
SW59C6 av   198  60 **     8    2   0.3    0.8    1.8    1801     1998
SW59C6 av   198  54        6    6   0.8    0.7    1.5    1792     1989
SW59C6 av   198  51        5    6   0.9    1.5    0.5    1800     1997
SW59C6 av   198  53        4   -5   0.7    0.4    0.9    1788     1985
SW59C6 av   198  53        4   -9   1.2    0.5    1.2    1785     1982
SW59C6 av   198  59 **     3    1   0.1    0.5    0.5    1796     1993
SW59C6 av   198  53        3    2   0.3    1.0    0.1    1806     2003
SW59C6 av   198  54        2   -1   0.2    0.1    0.6    1805     2002
SW59C6 av   198  51        2    2   0.3    0.8    0.1    1793     1990
SW59C6 av   198  51        2   -1   0.2    0.5    0.2    1798     1995
SW59C6 av   197  52        1   -3   0.4    0.5    0.0    1808     2005
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Sample    (=HalfCh): SW59C7 av                           0       153  1850  2002
Reference (=HalfCh): SW59C2 av                           0       230  1775  2004
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Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C7 av	153	63	***	27	15	1.9	4.3	4.4	1837	1989
SW59C7 av	153	55		10	4	0.5	1.7	2.0	1828	1980
SW59C7 av	153	51		8	0	0.0	1.2	2.0	1845	1997
SW59C7 av	153	56		7	15	1.9	1.4	1.2	1852	2004
SW59C7 av	153	53		7	5	0.6	1.4	1.2	1850	2002
SW59C7 av	153	54		6	7	0.8	1.2	0.9	1834	1986
SW59C7 av	153	55		4	-2	0.2	0.8	0.7	1835	1987
SW59C7 av	153	52		4	0	0.0	0.9	0.6	1842	1994
SW59C7 av	153	52		4	1	0.2	0.2	1.1	1847	1999
SW59C7 av	153	51		4	3	0.4	0.9	0.5	1848	2000
SW59C7 av	153	54		3	5	0.7	0.2	0.9	1849	2001
SW59C7 av	153	53		3	-2	0.3	0.7	0.5	1841	1993
SW59C7 av	153	52		3	3	0.3	0.5	0.8	1832	1984
SW59C7 av	153	52		3	-3	0.4	1.0	0.1	1830	1982
SW59C7 av	153	55		2	0	0.1	0.0	0.6	1843	1995
SW59C7 av	153	55		1	-12	1.5	0.0	0.3	1840	1992

Sample	(=HalfCh): SW59C9 av	0	163	1841	2003
Reference	(=HalfCh): SW59C2 av	0	230	1775	2004

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C9 av	163	60	**	13	13	1.7	2.2	2.0	1818	1980
SW59C9 av	163	57	*	12	8	1.0	1.8	2.2	1822	1984
SW59C9 av	163	48		10	-11	1.4	1.8	2.3	1821	1983
SW59C9 av	163	52		7	18	2.4	1.7	1.1	1834	1996
SW59C9 av	163	55		6	13	1.7	1.4	0.9	1830	1992
SW59C9 av	163	51		6	8	1.0	1.3	1.0	1841	2003
SW59C9 av	163	57	*	4	1	0.1	0.8	0.4	1826	1988
SW59C9 av	162	51		4	17	2.2	0.7	1.0	1843	2005
SW59C9 av	163	50		4	6	0.8	0.4	1.3	1820	1982
SW59C9 av	163	55		3	12	1.6	0.9	0.3	1839	2001
SW59C9 av	163	53		3	8	1.0	0.7	0.4	1836	1998
SW59C9 av	163	52		2	-2	0.3	0.7	0.2	1824	1986
SW59C9 av	163	51		2	10	1.3	0.4	0.4	1833	1995
SW59C9 av	163	50		2	14	1.8	0.3	0.4	1835	1997

Sample	(=HalfCh): SW59C1 av	0	212	1794	2005
Reference	(=HalfCh): SW59C5 av	0	206	1802	2007

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C1 av	183	56		11	8	1.1	1.8	2.3	1773	1984
SW59C1 av	199	51		7	3	0.5	1.7	1.2	1789	2000
SW59C1 av	193	50		7	-14	1.9	1.9	1.2	1783	1994
SW59C1 av	188	53		6	-3	0.4	1.6	0.6	1778	1989
SW59C1 av	196	55		5	-2	0.2	1.1	0.6	1786	1997
SW59C1 av	191	50		5	8	1.2	1.1	0.8	1781	1992
SW59C1 av	204	52		3	-1	0.1	0.2	0.9	1794	2005
SW59C1 av	202	52		3	5	0.7	0.8	0.6	1792	2003
SW59C1 av	200	51		2	2	0.2	0.4	0.3	1790	2001
SW59C1 av	185	51		2	-2	0.3	0.8	0.0	1775	1986
SW59C1 av	179	54		1	-6	0.8	0.4	0.1	1769	1980
SW59C1 av	194	51		1	-8	1.2	0.3	0.1	1784	1995

Sample	(=HalfCh): SW59C10 av	0	151	1854	2004
Reference	(=HalfCh): SW59C5 av	0	206	1802	2007

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C10 av	151	44		13	-24	3.1	2.3	3.4	1845	1995
SW59C10 av	151	45		12	-16	2.0	2.4	2.9	1855	2005
SW59C10 av	151	60	**	11	-1	0.1	1.4	2.4	1846	1996
SW59C10 av	151	58	*	9	-1	0.1	1.3	1.9	1852	2002
SW59C10 av	151	53		8	1	0.1	2.0	1.1	1838	1988
SW59C10 av	151	53		6	-1	0.2	0.8	1.4	1854	2004
SW59C10 av	151	53		6	-11	1.4	0.8	1.5	1844	1994
SW59C10 av	151	51		6	-3	0.4	1.0	1.4	1841	1991
SW59C10 av	151	51		5	-16	2.0	0.7	1.2	1842	1992
SW59C10 av	151	57	*	4	-4	0.5	0.3	1.0	1856	2006
SW59C10 av	151	53		4	2	0.2	0.9	0.7	1848	1998
SW59C10 av	151	52		4	-5	0.6	0.7	0.8	1835	1985
SW59C10 av	151	52		4	-9	1.0	1.2	0.2	1850	2000
SW59C10 av	151	51		4	-10	1.3	0.9	0.6	1840	1990
SW59C10 av	151	55		3	1	0.1	0.3	0.7	1831	1981
SW59C10 av	151	51		3	-4	0.5	0.2	0.8	1833	1983
SW59C10 av	151	51		3	-7	0.9	0.7	0.4	1832	1982
SW59C10 av	151	51		3	-8	1.0	0.2	0.9	1834	1984
SW59C10 av	151	50		2	-9	1.1	0.7	0.0	1837	1987
SW59C10 av	151	51		0	-5	0.7	0.1	0.1	1839	1989

Sample	(=HalfCh): SW59C11 av	0	177	1828	2004
Reference	(=HalfCh): SW59C5 av	0	206	1802	2007

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C11 av	177	54		7	-10	1.3	1.0	1.5	1809	1985
SW59C11 av	177	50		7	7	1.0	1.2	1.4	1816	1992
SW59C11 av	177	55		5	1	0.2	1.0	0.9	1824	2000
SW59C11 av	177	52		5	-4	0.5	1.1	0.8	1826	2002
SW59C11 av	177	51		4	-5	0.7	1.2	0.5	1828	2004
SW59C11 av	177	51		4	-1	0.1	0.7	0.7	1804	1980
SW59C11 av	177	52		3	-5	0.7	0.7	0.4	1806	1982
SW59C11 av	177	51		2	-5	0.6	0.6	0.1	1827	2003
SW59C11 av	177	55		1	-8	1.1	0.3	0.2	1813	1989
SW59C11 av	177	55		1	-9	1.2	0.1	0.3	1829	2005
SW59C11 av	177	53		1	-8	1.1	0.0	0.4	1812	1988
SW59C11 av	177	51		1	-3	0.4	0.0	0.3	1822	1998

Sample	(=HalfCh): SW59C2 av	0	230	1775	2004
Reference	(=HalfCh): SW59C5 av	0	206	1802	2007

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C2 av	204	41		11	-22	3.2	2.7	2.6	1776	2005
SW59C2 av	199	52		8	2	0.3	1.4	1.9	1771	2000
SW59C2 av	185	58	*	7	0	0.0	1.6	1.0	1757	1986
SW59C2 av	203	58	*	6	-12	1.7	0.5	1.6	1775	2004
SW59C2 av	201	53		6	-1	0.1	0.5	1.8	1773	2002
SW59C2 av	190	57	*	5	5	0.7	1.0	1.0	1762	1991
SW59C2 av	205	57	*	5	-14	2.0	0.6	1.1	1777	2006
SW59C2 av	189	53		5	6	0.8	1.3	0.6	1761	1990
SW59C2 av	194	52		5	4	0.6	1.0	1.1	1766	1995

SW59C2 av	183	51		5	-15	2.1	1.4	0.9	1755	1984
SW59C2 av	182	52		3	-7	0.9	0.8	0.5	1754	1983
SW59C2 av	198	52		3	-9	1.3	0.3	0.8	1770	1999
SW59C2 av	192	57	*	2	-4	0.5	0.2	0.6	1764	1993
SW59C2 av	181	53		2	-5	0.6	0.6	0.1	1753	1982
SW59C2 av	180	51		2	-6	0.8	0.8	0.1	1752	1981
SW59C2 av	187	51		2	-4	0.6	0.8	0.1	1759	1988
SW59C2 av	196	51		1	-7	0.9	0.4	0.0	1768	1997

Sample (=HalfCh): SW59C5 av 0 206 1802 2007
Reference (=HalfCh): SW59C5 av 0 206 1802 2007

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C5 av	204	51		25	7	0.9	8.3	1.8	1800	2005
SW59C5 av	185	58	*	20	31	4.4	3.5	3.8	1781	1986
SW59C5 av	192	51		13	-3	0.3	2.9	2.3	1788	1993
SW59C5 av	199	44		12	-7	1.0	2.7	2.8	1795	2000
SW59C5 av	205	34		12	30	4.4	2.6	4.6	1801	2006
SW59C5 av	194	56	*	11	17	2.4	2.2	1.8	1790	1995
SW59C5 av	197	55		11	13	1.8	2.6	1.3	1793	1998
SW59C5 av	195	50		8	4	0.6	2.0	1.4	1791	1996
SW59C5 av	181	61	**	7	4	0.6	1.5	1.1	1777	1982
SW59C5 av	190	53		6	12	1.7	1.9	0.6	1786	1991
SW59C5 av	187	50		6	14	1.9	1.3	1.2	1783	1988
SW59C5 av	183	55		5	3	0.4	2.0	0.1	1779	1984
SW59C5 av	202	51		5	11	1.6	2.0	0.1	1798	2003
SW59C5 av	189	55		4	2	0.3	0.7	0.8	1785	1990
SW59C5 av	198	54		4	3	0.4	0.5	0.8	1794	1999
SW59C5 av	179	52		3	2	0.3	0.9	0.2	1775	1980
SW59C5 av	203	51		3	8	1.1	1.1	0.2	1799	2004
SW59C5 av	200	52		2	3	0.4	0.0	0.9	1796	2001
SW59C5 av	201	51		2	5	0.7	0.5	0.3	1797	2002

Sample (=HalfCh): SW59C6 av 0 198 1806 2003
Reference (=HalfCh): SW59C5 av 0 206 1802 2007

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C6 av	198	44		11	-15	2.2	2.4	2.6	1804	2001
SW59C6 av	184	58	*	8	-6	0.8	1.1	1.6	1788	1985
SW59C6 av	198	53		7	0	0.0	1.2	1.2	1805	2002
SW59C6 av	190	56		6	-2	0.2	1.0	1.3	1794	1991
SW59C6 av	198	54		6	2	0.3	1.2	1.1	1806	2003
SW59C6 av	179	54		6	-5	0.7	1.0	1.2	1783	1980
SW59C6 av	197	56	*	5	-7	1.0	0.8	1.2	1801	1998
SW59C6 av	198	51		5	-6	0.9	0.3	1.8	1803	2000
SW59C6 av	181	55		4	-10	1.3	0.5	1.1	1785	1982
SW59C6 av	198	54		4	4	0.6	0.4	1.1	1808	2005
SW59C6 av	186	56		3	-6	0.8	0.5	0.5	1790	1987
SW59C6 av	188	56		2	-9	1.2	0.5	0.1	1792	1989
SW59C6 av	193	51		2	-6	0.9	0.4	0.4	1797	1994
SW59C6 av	194	50		2	-5	0.7	0.4	0.5	1798	1995
SW59C6 av	192	51		1	-5	0.7	0.1	0.3	1796	1993

Sample	(=HalfCh): SW59C7 av	0	153	1850	2002
Reference	(=HalfCh): SW59C5 av	0	206	1802	2007

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C7 av	153	62	**	15	13	1.6	2.1	2.6	1847	1999
SW59C7 av	153	44		10	-17	2.1	2.6	2.0	1829	1981
SW59C7 av	153	55		9	8	1.0	1.8	1.5	1839	1991
SW59C7 av	153	51		9	11	1.3	1.7	1.9	1843	1995
SW59C7 av	153	52		8	7	0.8	1.9	1.2	1834	1986
SW59C7 av	153	51		6	-7	0.9	1.0	1.2	1852	2004
SW59C7 av	153	53		5	-2	0.2	0.5	1.5	1838	1990
SW59C7 av	153	53		5	6	0.7	0.2	1.9	1845	1997
SW59C7 av	153	53		5	2	0.3	0.9	1.0	1828	1980
SW59C7 av	153	52		5	-10	1.2	1.4	0.5	1853	2005
SW59C7 av	153	52		4	5	0.7	0.9	0.5	1842	1994
SW59C7 av	153	55		2	1	0.1	0.3	0.4	1835	1987
SW59C7 av	153	54		2	-1	0.1	0.2	0.3	1850	2002
SW59C7 av	153	54		2	-5	0.7	0.4	0.3	1830	1982
SW59C7 av	153	52		1	5	0.6	0.0	0.2	1840	1992

Sample	(=HalfCh): SW59C9 av	0	163	1841	2003
Reference	(=HalfCh): SW59C5 av	0	206	1802	2007

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C9 av	163	46		12	-10	1.3	2.1	3.0	1844	2006
SW59C9 av	163	57	*	9	9	1.2	1.8	1.4	1841	2003
SW59C9 av	163	55		9	7	0.8	1.9	1.2	1828	1990
SW59C9 av	163	51		8	4	0.5	2.3	0.8	1825	1987
SW59C9 av	163	57	*	7	2	0.2	0.7	1.7	1822	1984
SW59C9 av	163	56		6	6	0.8	1.0	1.3	1820	1982
SW59C9 av	163	53		6	9	1.2	0.9	1.3	1837	1999
SW59C9 av	163	51		6	3	0.4	0.7	1.6	1843	2005
SW59C9 av	163	50		6	-8	1.1	1.7	0.8	1830	1992
SW59C9 av	163	55		4	-1	0.1	1.0	0.6	1832	1994
SW59C9 av	163	52		3	-3	0.3	1.0	0.4	1818	1980
SW59C9 av	163	56		2	-5	0.6	0.2	0.6	1824	1986
SW59C9 av	163	54		2	5	0.6	0.8	0.1	1836	1998
SW59C9 av	163	50		2	4	0.5	0.3	0.4	1835	1997
SW59C9 av	163	52		1	-1	0.2	0.4	0.0	1833	1995

Sample	(=HalfCh): SW59C1 av	0	212	1794	2005
Reference	(=HalfCh): SW59C6 av	0	198	1806	2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C1 av	177	58	*	14	22	3.0	2.1	2.9	1771	1982
SW59C1 av	188	56		10	14	2.0	1.8	2.0	1782	1993
SW59C1 av	196	55		8	11	1.5	1.3	1.5	1790	2001
SW59C1 av	190	53		5	7	0.9	0.3	1.5	1784	1995
SW59C1 av	198	52		5	5	0.7	1.3	0.5	1794	2005
SW59C1 av	193	52		4	6	0.9	0.8	0.9	1787	1998
SW59C1 av	184	50		4	10	1.3	0.6	1.0	1778	1989
SW59C1 av	182	58	*	3	19	2.5	0.6	0.7	1776	1987
SW59C1 av	175	55		3	7	0.9	0.0	1.3	1769	1980
SW59C1 av	198	52		3	3	0.5	0.6	0.4	1792	2003
SW59C1 av	178	51		3	13	1.7	0.1	1.1	1772	1983

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C1 av	186	50		3	3	0.4	0.9	0.2	1780	1991
SW59C1 av	191	52		2	4	0.5	0.3	0.4	1785	1996
SW59C1 av	197	51		2	11	1.5	0.9	0.0	1791	2002
SW59C1 av	185	50		2	3	0.5	0.1	0.8	1779	1990
SW59C1 av	198	51		1	12	1.6	0.3	0.1	1795	2006
SW59C1 av	194	52		0	5	0.7	0.0	0.1	1788	1999

Sample	(=HalfCh):	SW59C10 av	0	151	1854	2004
Reference	(=HalfCh):	SW59C6 av	0	198	1806	2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C10 av	151	53		15	16	2.0	3.2	2.5	1844	1994
SW59C10 av	148	46		13	-13	1.6	2.4	3.1	1856	2006
SW59C10 av	151	61	**	11	3	0.3	2.3	1.3	1841	1991
SW59C10 av	151	58	*	10	6	0.7	2.0	1.4	1852	2002
SW59C10 av	151	55		8	3	0.4	1.5	1.3	1848	1998
SW59C10 av	151	53		8	-2	0.2	1.5	1.5	1836	1986
SW59C10 av	149	52		8	5	0.6	1.1	1.9	1855	2005
SW59C10 av	151	54		3	-2	0.3	0.2	0.9	1845	1995
SW59C10 av	151	53		3	-3	0.4	0.6	0.4	1834	1984
SW59C10 av	151	51		3	1	0.2	0.4	0.6	1831	1981
SW59C10 av	151	52		2	-3	0.4	0.1	0.8	1847	1997
SW59C10 av	150	51		2	-5	0.7	0.3	0.5	1854	2004
SW59C10 av	151	50		2	-1	0.1	0.4	0.5	1851	2001
SW59C10 av	151	59	*	1	-8	1.0	0.2	0.0	1839	1989
SW59C10 av	151	51		1	1	0.1	0.4	0.1	1830	1980
SW59C10 av	151	50		1	0	0.0	0.1	0.4	1833	1983
SW59C10 av	151	52		0	-4	0.5	0.1	0.1	1835	1985

Sample	(=HalfCh):	SW59C11 av	0	177	1828	2004
Reference	(=HalfCh):	SW59C6 av	0	198	1806	2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C11 av	177	52		11	-7	1.0	1.8	2.5	1813	1989
SW59C11 av	177	55		10	8	1.0	1.2	2.5	1814	1990
SW59C11 av	177	59	*	9	6	0.8	0.5	2.6	1816	1992
SW59C11 av	177	54		7	4	0.5	1.0	1.7	1818	1994
SW59C11 av	177	53		7	4	0.5	1.2	1.4	1827	2003
SW59C11 av	176	55		6	-8	1.0	0.9	1.2	1828	2004
SW59C11 av	177	52		6	9	1.2	0.9	1.4	1812	1988
SW59C11 av	174	51		6	0	0.0	1.4	0.9	1830	2006
SW59C11 av	177	50		5	9	1.2	1.1	1.0	1825	2001
SW59C11 av	177	57	*	4	10	1.3	0.6	0.7	1824	2000
SW59C11 av	177	51		4	4	0.6	0.6	1.0	1822	1998
SW59C11 av	177	52		1	-5	0.6	0.1	0.3	1806	1982
SW59C11 av	177	50		1	-3	0.4	0.5	0.0	1810	1986
SW59C11 av	177	50		1	-10	1.3	0.2	0.2	1807	1983

Sample	(=HalfCh):	SW59C2 av	0	230	1775	2004
Reference	(=HalfCh):	SW59C6 av	0	198	1806	2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C2 av	190	49		11	-1	0.1	2.5	2.3	1766	1995
SW59C2 av	185	53		7	13	1.8	1.0	1.7	1761	1990

SW59C2 av	178	55		6	9	1.2	1.1	1.2	1754	1983
SW59C2 av	191	51		6	15	2.1	1.0	1.4	1767	1996
SW59C2 av	193	56	*	4	12	1.7	0.3	1.2	1769	1998
SW59C2 av	176	56		4	3	0.4	0.5	0.9	1752	1981
SW59C2 av	179	53		4	10	1.3	0.9	0.5	1755	1984
SW59C2 av	195	52		4	9	1.3	0.7	0.9	1771	2000
SW59C2 av	198	53		3	2	0.3	1.0	0.1	1775	2004
SW59C2 av	186	52		3	8	1.1	0.3	0.8	1762	1991
SW59C2 av	192	50		3	15	2.0	1.2	0.0	1768	1997
SW59C2 av	198	54		2	-1	0.2	0.1	0.6	1776	2005
SW59C2 av	189	52		2	8	1.0	0.5	0.5	1765	1994
SW59C2 av	197	52		1	-3	0.4	0.5	0.0	1773	2002

Sample (=HalfCh): SW59C5 av 0 206 1802 2007
Reference (=HalfCh): SW59C6 av 0 198 1806 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C5 av	179	56	*	14	5	0.7	2.9	2.4	1779	1984
SW59C5 av	176	55		12	-4	0.6	2.9	1.8	1776	1981
SW59C5 av	192	50		9	1	0.1	2.1	1.7	1792	1997
SW59C5 av	186	51		6	-9	1.3	1.6	0.9	1786	1991
SW59C5 av	197	54		5	-1	0.2	1.0	1.0	1797	2002
SW59C5 av	182	53		5	-6	0.8	1.0	1.2	1782	1987
SW59C5 av	190	52		5	-15	2.1	1.2	0.8	1790	1995
SW59C5 av	198	54		4	4	0.6	0.4	1.1	1800	2005
SW59C5 av	177	53		4	-12	1.6	1.0	0.5	1777	1982
SW59C5 av	191	55		3	-6	0.9	0.5	0.6	1791	1996
SW59C5 av	183	55		3	-7	0.9	0.8	0.2	1783	1988
SW59C5 av	189	51		3	-14	1.9	0.3	0.8	1789	1994
SW59C5 av	195	52		2	-11	1.5	0.2	0.4	1795	2000
SW59C5 av	185	52		1	-12	1.6	0.4	0.0	1785	1990
SW59C5 av	187	51		0	-13	1.7	0.0	0.2	1787	1992

Sample (=HalfCh): SW59C6 av 0 198 1806 2003
Reference (=HalfCh): SW59C6 av 0 198 1806 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C6 av	198	100	***	1000	100	100.0	100.0	100.0	1806	2003
SW59C6 av	197	36		17	35	5.3	3.0	6.5	1805	2002
SW59C6 av	197	36		17	35	5.3	3.0	6.5	1807	2004
SW59C6 av	196	46		15	25	3.6	6.2	0.5	1804	2001
SW59C6 av	196	46		15	25	3.6	6.2	0.5	1808	2005
SW59C6 av	185	53		14	28	3.9	2.5	2.7	1793	1990
SW59C6 av	178	57	*	10	31	4.3	1.8	2.0	1786	1983
SW59C6 av	192	55		10	30	4.3	1.6	1.9	1800	1997
SW59C6 av	194	51		5	27	3.8	1.1	0.9	1802	1999
SW59C6 av	187	56	*	4	19	2.6	0.2	1.1	1795	1992
SW59C6 av	184	53		3	19	2.6	0.2	1.0	1792	1989
SW59C6 av	195	51		3	19	2.7	0.2	1.0	1803	2000
SW59C6 av	195	51		3	19	2.7	0.2	1.0	1809	2006
SW59C6 av	181	52		2	15	2.0	0.3	0.6	1789	1986
SW59C6 av	180	51		2	25	3.5	0.1	0.7	1788	1985
SW59C6 av	189	50		2	14	2.0	0.4	0.3	1797	1994
SW59C6 av	175	55		1	19	2.6	0.5	0.1	1783	1980

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SW59C6 av   182  53         1   14   1.8   0.2   0.1   1790   1987
SW59C6 av   188  52         1   19   2.6   0.3   0.0   1796   1993
-------------------------------------------------------------------

Sample    (=HalfCh): SW59C7 av                          0      153  1850  2002
Reference (=HalfCh): SW59C6 av                          0      198  1806  2003

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
SW59C7 av   153  60 **     17   37   4.8   3.2   2.3   1840   1992
SW59C7 av   153  55        13   25   3.1   2.3   2.5   1845   1997
SW59C7 av   150  53        10   16   2.0   2.1   1.7   1854   2006
SW59C7 av   153  52        10   20   2.5   2.4   1.3   1833   1985
SW59C7 av   153  43        10    7   0.9   2.4   2.5   1841   1993
SW59C7 av   153  58 *       8   14   1.7   0.9   1.9   1848   2000
SW59C7 av   153  51         8    2   0.2   2.1   1.1   1831   1983
SW59C7 av   153  53         7   17   2.1   1.3   1.5   1850   2002
SW59C7 av   153  51         5    3   0.3   0.9   1.2   1844   1996
SW59C7 av   153  51         5    7   0.9   1.2   0.8   1847   1999
SW59C7 av   153  55         4   17   2.1   0.7   0.6   1837   1989
SW59C7 av   153  53         3    7   0.9   0.6   0.6   1843   1995
SW59C7 av   153  51         3   -1   0.1   1.1   0.1   1842   1994
SW59C7 av   153  50         3    9   1.1   0.4   0.8   1836   1988
SW59C7 av   153  50         2    9   1.2   0.5   0.3   1830   1982
SW59C7 av   153  53         1   10   1.2   0.2   0.3   1851   2003
SW59C7 av   151  52         1    9   1.1   0.3   0.1   1853   2005
-------------------------------------------------------------------

Sample    (=HalfCh): SW59C9 av                          0      163  1841  2003
Reference (=HalfCh): SW59C6 av                          0      198  1806  2003


  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
SW59C9 av   163  53        15   29   3.9   2.9   2.8   1827   1989
SW59C9 av   163  45        14  -23   3.0   3.0   3.4   1830   1992
SW59C9 av   163  52         9    5   0.7   1.5   1.9   1831   1993
SW59C9 av   163  57 *       7   11   1.4   1.3   1.3   1834   1996
SW59C9 av   163  57 *       6    7   0.9   1.3   1.0   1838   2000
SW59C9 av   163  54         5    4   0.5   0.4   1.3   1840   2002
SW59C9 av   163  54         5    1   0.1   0.3   1.4   1828   1990
SW59C9 av   163  52         5    9   1.1   0.8   1.1   1818   1980
SW59C9 av   163  52         5   11   1.4   1.3   0.7   1822   1984
SW59C9 av   163  52         4    2   0.2   1.1   0.3   1837   1999
SW59C9 av   163  50         4    0   0.0   0.6   1.0   1819   1981
SW59C9 av   163  50         4   -4   0.5   1.1   0.6   1829   1991
SW59C9 av   163  53         3   -2   0.3   0.5   0.4   1841   2003
SW59C9 av   163  52         3   12   1.6   0.4   0.8   1833   1995
SW59C9 av   163  50         3    7   0.9   0.8   0.5   1832   1994
SW59C9 av   163  55         2    8   1.0   0.4   0.4   1821   1983
SW59C9 av   162  51         0    1   0.1   0.1   0.0   1842   2004
-------------------------------------------------------------------

Sample    (=HalfCh): SW59C1 av                          0      212  1794  2005
Reference (=HalfCh): SW59C7 av                          0      153  1850  2002

  Sample    OVL Glk GSL   CDI  %CC    TV  TVBP  TVH   DateL  DateR
SW59C1 av   133  59 *      20   29   3.5   4.0   3.2   1771   1982
SW59C1 av   153  57 *      14   18   2.2   2.6   2.3   1792   2003
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SW59C1 av	153	44		11	-1	0.1	2.4	2.4	1791	2002
SW59C1 av	148	55		10	22	2.7	2.1	1.6	1786	1997
SW59C1 av	141	47		10	-16	1.9	2.0	2.2	1779	1990
SW59C1 av	151	57	*	7	17	2.1	1.4	1.0	1789	2000
SW59C1 av	138	53		6	14	1.7	0.9	1.4	1776	1987
SW59C1 av	145	51		5	6	0.7	0.7	1.3	1783	1994
SW59C1 av	140	57		4	1	0.2	0.3	1.1	1778	1989
SW59C1 av	143	54		4	4	0.5	0.9	0.7	1781	1992
SW59C1 av	142	53		4	4	0.5	0.7	0.8	1780	1991
SW59C1 av	153	50		3	1	0.1	0.8	0.4	1793	2004
SW59C1 av	153	56		2	-2	0.3	0.7	0.0	1795	2006
SW59C1 av	132	53		2	11	1.3	0.6	0.1	1770	1981
SW59C1 av	152	52		1	11	1.4	0.0	0.5	1790	2001
SW59C1 av	136	51		1	5	0.6	0.2	0.1	1774	1985
SW59C1 av	147	50		1	10	1.2	0.5	0.1	1785	1996

Sample	(=HalfCh):	SW59C10 av	0	151	1854	2004
Reference	(=HalfCh):	SW59C7 av	0	153	1850	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C10 av	146	46		11	-12	1.4	1.7	3.0	1845	1995
SW59C10 av	145	57	*	8	8	1.0	0.7	2.1	1844	1994
SW59C10 av	147	53		8	8	0.9	1.4	1.8	1846	1996
SW59C10 av	148	51		8	-6	0.7	1.8	1.2	1855	2005
SW59C10 av	137	51		8	13	1.5	2.0	1.2	1836	1986
SW59C10 av	151	50		8	9	1.1	1.7	1.6	1851	2001
SW59C10 av	149	52		7	6	0.7	1.6	1.3	1854	2004
SW59C10 av	139	54		6	-12	1.4	1.3	0.9	1838	1988
SW59C10 av	136	52		5	14	1.6	0.9	1.1	1835	1985
SW59C10 av	147	50		5	-4	0.5	1.0	1.0	1856	2006
SW59C10 av	142	52		4	5	0.6	0.9	0.8	1841	1991
SW59C10 av	150	52		3	4	0.5	0.7	0.5	1853	2003
SW59C10 av	131	52		2	-1	0.1	0.6	0.3	1830	1980
SW59C10 av	134	51		2	-2	0.2	0.2	0.6	1833	1983
SW59C10 av	151	50		2	-11	1.3	0.4	0.6	1850	2000
SW59C10 av	141	51		1	5	0.6	0.3	0.1	1840	1990
SW59C10 av	150	52		0	-6	0.8	0.1	0.0	1849	1999

Sample	(=HalfCh):	SW59C11 av	0	177	1828	2004
Reference	(=HalfCh):	SW59C7 av	0	153	1850	2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C11 av	143	58	*	14	12	1.4	2.7	2.4	1816	1992
SW59C11 av	146	58	*	11	-3	0.4	1.8	2.0	1819	1995
SW59C11 av	153	57	*	10	13	1.6	1.7	1.8	1827	2003
SW59C11 av	132	41		10	-21	2.5	2.5	2.8	1805	1981
SW59C11 av	131	59	*	8	2	0.2	1.3	1.6	1804	1980
SW59C11 av	153	55		8	8	1.0	1.7	1.0	1830	2006
SW59C11 av	139	54		8	10	1.2	1.7	1.5	1812	1988
SW59C11 av	148	57		5	-4	0.4	0.6	1.4	1821	1997
SW59C11 av	136	50		5	-9	1.0	1.2	1.1	1809	1985
SW59C11 av	134	55		4	-3	0.3	1.4	0.2	1807	1983
SW59C11 av	151	59	*	3	1	0.1	0.6	0.5	1824	2000

SW59C11 av	135	52		3	-4	0.4	0.4	0.6	1808	1984
SW59C11 av	138	50		1	2	0.2	0.1	0.5	1811	1987
SW59C11 av	140	50		1	4	0.5	0.1	0.2	1813	1989
SW59C11 av	150	50		1	-2	0.2	0.2	0.1	1823	1999

Sample (=HalfCh): SW59C2 av 0 230 1775 2004
Reference (=HalfCh): SW59C7 av 0 153 1850 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C2 av	147	57	*	8	12	1.5	1.4	1.6	1767	1996
SW59C2 av	153	56		7	15	1.9	1.4	1.2	1773	2002
SW59C2 av	153	53		7	5	0.6	1.4	1.2	1775	2004
SW59C2 av	144	50		7	6	0.7	1.6	1.3	1764	1993
SW59C2 av	137	54		6	20	2.3	1.0	1.2	1757	1986
SW59C2 av	153	51		4	3	0.4	0.9	0.5	1777	2006
SW59C2 av	136	50		4	22	2.6	1.2	0.3	1756	1985
SW59C2 av	153	54		3	5	0.7	0.2	0.9	1776	2005
SW59C2 av	142	55		2	-4	0.4	0.7	0.0	1762	1991
SW59C2 av	132	53		2	5	0.6	0.3	0.5	1752	1981
SW59C2 av	140	53		2	13	1.6	0.8	0.2	1760	1989
SW59C2 av	134	51		2	7	0.8	0.2	0.5	1754	1983
SW59C2 av	150	50		2	-4	0.5	0.3	0.4	1770	1999
SW59C2 av	131	56		1	8	0.9	0.3	0.0	1751	1980
SW59C2 av	145	54		0	4	0.5	0.1	0.0	1765	1994

Sample (=HalfCh): SW59C5 av 0 206 1802 2007
Reference (=HalfCh): SW59C7 av 0 153 1850 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C5 av	153	51		15	6	0.8	3.2	2.5	1797	2002
SW59C5 av	133	46		11	-8	0.9	2.4	2.6	1777	1982
SW59C5 av	140	54		7	9	1.0	1.3	1.5	1784	1989
SW59C5 av	153	51		6	-7	0.9	1.0	1.2	1800	2005
SW59C5 av	145	58	*	5	3	0.4	0.9	0.8	1789	1994
SW59C5 av	153	52		5	-10	1.2	1.4	0.5	1799	2004
SW59C5 av	131	50		5	10	1.2	1.7	0.6	1775	1980
SW59C5 av	134	56		4	4	0.5	0.5	1.2	1778	1983
SW59C5 av	150	55		3	-4	0.5	0.3	0.8	1794	1999
SW59C5 av	143	55		3	1	0.1	0.5	0.6	1787	1992
SW59C5 av	138	51		3	-1	0.2	1.0	0.4	1782	1987
SW59C5 av	152	55		2	-6	0.7	0.6	0.0	1796	2001
SW59C5 av	146	53		2	3	0.4	0.5	0.4	1790	1995
SW59C5 av	132	52		2	0	0.0	0.0	0.6	1776	1981
SW59C5 av	141	50		2	-2	0.2	0.3	0.6	1785	1990
SW59C5 av	136	60	*	1	9	1.0	0.4	0.1	1780	1985
SW59C5 av	148	52		1	1	0.1	0.1	0.4	1792	1997
SW59C5 av	142	51		1	4	0.4	0.0	0.4	1786	1991

Sample (=HalfCh): SW59C6 av 0 198 1806 2003
Reference (=HalfCh): SW59C7 av 0 153 1850 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C6 av	150	53		10	16	2.0	2.1	1.7	1802	1999

SW59C6 av	133	60	**	8	18	2.1	1.3	1.4	1785	1982
SW59C6 av	153	58	*	8	14	1.7	0.9	1.9	1808	2005
SW59C6 av	153	53		7	17	2.1	1.3	1.5	1806	2003
SW59C6 av	145	52		7	1	0.1	1.6	1.2	1797	1994
SW59C6 av	153	51		5	7	0.9	1.2	0.8	1809	2006
SW59C6 av	146	52		4	17	2.1	1.1	0.5	1798	1995
SW59C6 av	136	56		3	4	0.5	0.4	0.8	1788	1985
SW59C6 av	142	52		3	1	0.1	0.5	0.7	1794	1991
SW59C6 av	153	53		1	10	1.2	0.2	0.3	1805	2002
SW59C6 av	139	52		1	7	0.8	0.5	0.0	1791	1988
SW59C6 av	141	52		1	1	0.2	0.3	0.1	1793	1990
SW59C6 av	151	52		1	9	1.1	0.3	0.1	1803	2000
SW59C6 av	134	56		0	9	1.1	0.0	0.0	1786	1983

Sample (=HalfCh): SW59C7 av 0 153 1850 2002
Reference (=HalfCh): SW59C7 av 0 153 1850 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C7 av	153	100	***	1000	100	100.0	100.0	100.0	1850	2002
SW59C7 av	151	46		16	1	0.1	5.8	1.1	1848	2000
SW59C7 av	151	46		16	1	0.1	5.8	1.1	1852	2004
SW59C7 av	152	35		15	15	1.8	3.0	5.8	1851	2003
SW59C7 av	152	35		15	15	1.8	3.0	5.8	1849	2001
SW59C7 av	132	51		7	5	0.5	1.5	1.6	1829	1981
SW59C7 av	141	55		5	12	1.4	1.2	0.9	1838	1990
SW59C7 av	146	51		5	15	1.8	0.9	1.0	1843	1995
SW59C7 av	150	57	*	4	2	0.3	1.2	0.2	1847	1999
SW59C7 av	150	57	*	4	2	0.3	1.2	0.2	1853	2005
SW59C7 av	142	54		4	8	1.0	1.0	0.4	1839	1991
SW59C7 av	145	52		4	0	0.1	0.6	0.8	1842	1994
SW59C7 av	137	50		4	16	1.8	0.8	0.9	1834	1986
SW59C7 av	131	52		3	6	0.7	1.0	0.1	1828	1980
SW59C7 av	148	53		1	11	1.4	0.1	0.2	1845	1997
SW59C7 av	136	52		1	19	2.2	0.2	0.1	1833	1985
SW59C7 av	138	51		1	7	0.8	0.2	0.3	1835	1987
SW59C7 av	135	50		1	13	1.5	0.2	0.4	1832	1984

Sample (=HalfCh): SW59C9 av 0 163 1841 2003
Reference (=HalfCh): SW59C7 av 0 153 1850 2002

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C9 av	138	63	**	12	24	2.9	1.4	2.4	1825	1987
SW59C9 av	153	58	*	12	16	2.0	2.5	1.7	1844	2006
SW59C9 av	136	54		9	12	1.4	1.6	2.2	1823	1985
SW59C9 av	144	58	*	7	11	1.3	1.4	1.1	1831	1993
SW59C9 av	141	54		7	20	2.4	1.7	1.1	1828	1990
SW59C9 av	134	55		5	-2	0.2	1.4	0.6	1821	1983
SW59C9 av	148	53		5	13	1.5	0.7	1.1	1835	1997
SW59C9 av	133	55		3	16	1.8	0.6	0.6	1820	1982
SW59C9 av	131	53		3	21	2.4	0.4	0.7	1818	1980
SW59C9 av	149	52		3	15	1.9	0.0	1.1	1836	1998
SW59C9 av	146	50		3	-2	0.3	1.0	0.3	1833	1995
SW59C9 av	152	53		2	1	0.1	0.2	0.5	1839	2001

Sample (=HalfCh): SW59C1 av 0 212 1794 2005
Reference (=HalfCh): SW59C9 av 0 163 1841 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C1 av	159	46		10	-10	1.3	2.1	2.1	1788	1999
SW59C1 av	163	53		8	12	1.5	1.0	1.9	1792	2003
SW59C1 av	140	54		5	10	1.2	1.4	0.5	1769	1980
SW59C1 av	158	52		5	4	0.5	0.6	1.3	1787	1998
SW59C1 av	160	51		5	11	1.4	0.8	1.2	1789	2000
SW59C1 av	144	55		4	15	1.8	0.9	0.8	1773	1984
SW59C1 av	163	53		4	9	1.2	0.2	1.3	1794	2005
SW59C1 av	150	53		4	13	1.5	0.5	1.0	1779	1990
SW59C1 av	157	55		3	-4	0.5	0.0	1.0	1786	1997
SW59C1 av	149	52		3	12	1.4	1.0	0.3	1778	1989
SW59C1 av	146	51		3	13	1.5	0.7	0.7	1775	1986
SW59C1 av	162	55		2	7	0.9	0.5	0.3	1791	2002
SW59C1 av	154	55		2	2	0.3	0.1	0.5	1783	1994
SW59C1 av	155	52		2	4	0.5	0.4	0.4	1784	1995
SW59C1 av	143	51		1	5	0.7	0.1	0.2	1772	1983
SW59C1 av	145	50		1	15	1.8	0.2	0.2	1774	1985

Sample (=HalfCh): SW59C10 av 0 151 1854 2004
Reference (=HalfCh): SW59C9 av 0 163 1841 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C10 av	142	42		14	-21	2.5	3.7	3.3	1832	1982
SW59C10 av	151	53		12	20	2.5	1.8	2.7	1852	2002
SW59C10 av	145	57		11	13	1.6	2.1	1.9	1835	1985
SW59C10 av	151	53		11	19	2.4	2.0	2.1	1844	1994
SW59C10 av	141	51		11	10	1.2	1.8	2.5	1831	1981
SW59C10 av	151	56		9	18	2.2	1.5	1.7	1848	1998
SW59C10 av	140	52		6	-3	0.4	1.4	0.9	1830	1980
SW59C10 av	148	56		5	11	1.4	0.8	1.0	1856	2006
SW59C10 av	144	52		5	3	0.4	1.8	0.1	1834	1984
SW59C10 av	149	52		5	22	2.7	1.0	0.8	1839	1989
SW59C10 av	151	50		4	4	0.5	1.5	0.1	1846	1996
SW59C10 av	148	56		3	9	1.1	0.9	0.1	1838	1988
SW59C10 av	151	53		3	12	1.4	0.1	1.2	1849	1999
SW59C10 av	150	53		3	8	1.0	0.1	1.2	1854	2004
SW59C10 av	143	52		3	0	0.0	0.6	0.7	1833	1983
SW59C10 av	151	50		3	8	0.9	0.1	1.1	1845	1995
SW59C10 av	151	55		2	15	1.9	0.1	0.6	1842	1992

Sample (=HalfCh): SW59C11 av 0 177 1828 2004
Reference (=HalfCh): SW59C9 av 0 163 1841 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C11 av	161	55		11	15	1.9	2.3	1.6	1825	2001
SW59C11 av	148	55		10	15	1.9	1.8	2.0	1812	1988
SW59C11 av	140	49		10	-6	0.7	1.8	2.4	1804	1980
SW59C11 av	145	54		8	12	1.5	2.0	1.1	1809	1985
SW59C11 av	146	52		5	3	0.3	1.5	0.6	1810	1986
SW59C11 av	142	58	*	4	5	0.6	0.8	0.5	1806	1982
SW59C11 av	155	52		4	9	1.1	0.9	0.7	1819	1995
SW59C11 av	159	52		4	0	0.0	1.0	0.5	1823	1999

SW59C11 av	163	53		3	9	1.1	0.7	0.5	1828	2004
SW59C11 av	149	52		3	4	0.5	0.2	1.0	1813	1989
SW59C11 av	158	51		3	-4	0.5	0.7	0.4	1822	1998
SW59C11 av	152	52		2	0	0.1	0.2	0.5	1816	1992
SW59C11 av	151	51		2	-3	0.4	0.1	0.6	1815	1991
SW59C11 av	156	53		1	5	0.6	0.0	0.4	1820	1996
SW59C11 av	163	52		1	10	1.3	0.1	0.3	1829	2005

Sample (=HalfCh): SW59C2 av 0 230 1775 2004
Reference (=HalfCh): SW59C9 av 0 163 1841 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C2 av	158	53		6	20	2.5	0.5	1.9	1769	1998
SW59C2 av	147	52		6	12	1.5	1.1	1.2	1758	1987
SW59C2 av	163	51		6	8	1.0	1.3	1.0	1775	2004
SW59C2 av	145	55		5	10	1.3	0.4	1.7	1756	1985
SW59C2 av	143	52		5	15	1.9	1.0	1.1	1754	1983
SW59C2 av	160	51		5	15	1.9	0.3	1.5	1771	2000
SW59C2 av	156	55		4	16	2.0	0.5	0.9	1767	1996
SW59C2 av	152	51		4	16	2.0	0.7	0.8	1763	1992
SW59C2 av	162	51		4	17	2.2	0.7	1.0	1773	2002
SW59C2 av	163	55		3	12	1.6	0.9	0.3	1777	2006
SW59C2 av	140	51		3	6	0.8	0.6	0.9	1751	1980
SW59C2 av	144	51		3	2	0.2	0.2	1.0	1755	1984
SW59C2 av	150	51		2	18	2.2	0.5	0.4	1761	1990
SW59C2 av	153	53		1	10	1.2	0.0	0.2	1764	1993
SW59C2 av	154	51		1	15	1.9	0.4	0.0	1765	1994
SW59C2 av	149	51		1	11	1.3	0.1	0.4	1760	1989

Sample (=HalfCh): SW59C5 av 0 206 1802 2007
Reference (=HalfCh): SW59C9 av 0 163 1841 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C5 av	163	60	**	17	3	0.4	2.7	3.0	1798	2003
SW59C5 av	163	46		12	-10	1.3	2.1	3.0	1799	2004
SW59C5 av	155	59	*	6	0	0.0	1.2	1.0	1790	1995
SW59C5 av	144	56		6	2	0.3	1.3	1.2	1779	1984
SW59C5 av	163	51		6	3	0.4	0.7	1.6	1800	2005
SW59C5 av	151	61	**	5	5	0.6	1.1	0.7	1786	1991
SW59C5 av	159	54		4	-3	0.3	0.5	1.0	1794	1999
SW59C5 av	142	54		4	-7	0.8	0.2	1.2	1777	1982
SW59C5 av	161	54		3	-5	0.6	1.0	0.1	1796	2001
SW59C5 av	153	51		3	-2	0.3	0.8	0.2	1788	1993
SW59C5 av	148	54		2	-4	0.5	0.2	0.7	1783	1988
SW59C5 av	146	53		2	-5	0.6	0.5	0.2	1781	1986
SW59C5 av	157	51		2	-4	0.4	0.1	0.6	1792	1997
SW59C5 av	140	52		1	-7	0.8	0.3	0.1	1775	1980

Sample (=HalfCh): SW59C6 av 0 198 1806 2003
Reference (=HalfCh): SW59C9 av 0 163 1841 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C6 av	157	52		12	13	1.7	3.0	1.8	1800	1997
SW59C6 av	163	57	*	6	7	0.9	1.3	1.0	1809	2006

SW59C6 av	153	56		6	6	0.7	1.7	0.3	1796	1993
SW59C6 av	150	53		6	10	1.2	1.0	1.4	1793	1990
SW59C6 av	147	57	*	5	-2	0.3	0.5	1.2	1790	1987
SW59C6 av	163	54		5	4	0.5	0.4	1.3	1807	2004
SW59C6 av	152	51		5	7	0.8	0.8	1.4	1795	1992
SW59C6 av	141	56		4	0	0.0	0.5	1.0	1784	1981
SW59C6 av	158	54		4	7	0.8	0.9	0.7	1801	1998
SW59C6 av	149	50		4	-4	0.5	0.4	1.2	1792	1989
SW59C6 av	163	53		3	-2	0.3	0.5	0.4	1806	2003
SW59C6 av	140	50		3	3	0.4	0.9	0.2	1783	1980
SW59C6 av	162	51		0	1	0.1	0.1	0.0	1805	2002

Sample (=HalfCh): SW59C7 av 0 153 1850 2002
Reference (=HalfCh): SW59C9 av 0 163 1841 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C7 av	153	55		13	17	2.2	2.8	1.8	1843	1995
SW59C7 av	153	58	*	12	16	2.0	2.5	1.7	1847	1999
SW59C7 av	143	52		7	-4	0.5	1.6	1.3	1831	1983
SW59C7 av	149	56		6	9	1.1	0.8	1.5	1837	1989
SW59C7 av	140	54		6	9	1.1	1.0	1.3	1828	1980
SW59C7 av	151	58	*	5	1	0.1	0.6	1.2	1839	1991
SW59C7 av	147	55		5	8	0.9	0.7	1.2	1835	1987
SW59C7 av	153	54		3	6	0.8	0.9	0.1	1844	1996
SW59C7 av	152	53		3	-3	0.3	1.0	0.0	1840	1992
SW59C7 av	152	53		2	1	0.1	0.2	0.5	1852	2004
SW59C7 av	142	53		2	-7	0.8	0.5	0.3	1830	1982
SW59C7 av	145	51		2	-6	0.7	0.5	0.3	1833	1985

Sample (=HalfCh): SW59C9 av 0 163 1841 2003
Reference (=HalfCh): SW59C9 av 0 163 1841 2003

Sample	OVL	Glk	GSL	CDI	%CC	TV	TVBP	TVH	DateL	DateR
SW59C9 av	163	100	***	1000	100	100.0	100.0	100.0	1841	2003
SW59C9 av	162	33		20	10	1.3	3.6	8.4	1840	2002
SW59C9 av	162	33		20	10	1.3	3.6	8.4	1842	2004
SW59C9 av	159	58	*	14	13	1.6	2.0	2.9	1837	1999
SW59C9 av	161	50		14	21	2.7	3.2	2.6	1839	2001
SW59C9 av	161	50		14	21	2.7	3.2	2.6	1843	2005
SW59C9 av	160	44		12	-7	0.9	1.6	3.7	1838	2000
SW59C9 av	160	44		12	-7	0.9	1.6	3.7	1844	2006
SW59C9 av	147	55		10	10	1.2	2.5	1.4	1825	1987
SW59C9 av	146	49		10	-8	0.9	2.4	1.9	1824	1986
SW59C9 av	157	53		8	12	1.5	0.8	2.4	1835	1997
SW59C9 av	153	53		7	19	2.4	1.4	1.3	1831	1993
SW59C9 av	144	61	**	6	12	1.4	1.5	0.8	1822	1984
SW59C9 av	155	58	*	5	18	2.3	0.4	1.3	1833	1995
SW59C9 av	150	56		5	15	1.8	1.0	0.9	1828	1990
SW59C9 av	142	58	*	3	6	0.8	0.3	0.8	1820	1982
SW59C9 av	140	55		2	5	0.5	0.4	0.4	1818	1980
SW59C9 av	151	53		1	8	1.0	0.0	0.5	1829	1991

*** End of cross-date job. ***